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The hidden history and science of bisexuality

In this provocative and eye-opening talk, psychologist Julia Shaw explores how people have defined and measured bisexuality across history. Learn about some famous bisexual and pansexual activists and scholars whom everyone should know, and be challenged to think deeper about who we are and how we love.

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Weekender

The science of rewilding: Coombeshead, UK

Discover how nature is making a comeback in the scenic Devon countryside. Accompanied by *New Scientist* staff writer Graham Lawton, you will learn how rewilding allows nature to take care of itself, as you experience a walking safari, observe animals in the breeding centre and go beaver watching. This weekend runs from 1 to 3 September and costs £649.

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Podcast

Weekly

The team tackles the ongoing saga of a possible room-temperature, ambient-pressure superconductor. We also hear how NASA briefly lost the Voyager 2 space probe. Plus, the first round of images from the Euclid space telescope, which was sent to hunt dark matter, are now in. And should we all get blood tests for Alzheimer's?

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Weekender



CAVAN IMAGES/ALAMY

Beaver spotting Go wild in Devon, UK, on our first weekend tour

Podcast



NASA/JPL-CALTECH

Lost in space NASA's blunder left Voyager 2 briefly stranded

Video

Climate anxiety

The Umbrella Academy actor and climate activist Aidan Gallagher uses social media to help people overcome eco-anxiety. "A lot of times, when you look at an issue as big as these global crises, there's a choice," he says. "You can either go down the feeling of, 'I'm only me, what can I do?', or you can go, 'I'm only me, I'm going to do what I can'."

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Newsletter

Health Check

The importance of our microbiome is well-known, but there are lots of misconceptions too. Clare Wilson unpicks the three biggest microbiome myths. Do bacteria outnumber human cells 10 to 1? Can the microbiome explain a host of modern diseases? And is there any point in taking probiotics?

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Newsletter

"Many strong claims made about the microbiome have been overturned by later research"



Essential guide

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Kicking up a stink

We need political intervention and joined-up thinking to end sewage pollution crises

THE UK has a very mucky problem. News feeds overflow with videos of raw sewage gushing into rivers during heavy rain. In our report (see page 36), we explore why the country still dumps untreated waste into waterways and how to fix this. The solution, it turns out, includes thinking about the water system as a whole: tackling sewage pollution is also about fixing flooding and drought problems. Tougher governance is essential, too.

The UK isn't alone. In Australia, Sydney Water recently agreed to pay \$347,100 for environmental and community works after a broken pipe caused more than 3 million litres of untreated sewage to overflow into several watercourses. As in the UK, the solutions involve joined-up thinking: Australia is short of water, and

would do well to recycle treated sewage water rather than dumping it in the sea.

The US has similar issues. In recent months, coastal swimming areas in Long Beach, California, had to close temporarily due to sewage spills. Meanwhile, like much of the UK, a lot of New York City has

"Tackling the issue of sewage spills is also about fixing the flooding and drought problems"

a combined sewage system that carries domestic waste and runoff, so heavy rain sees sewage systems unable to cope and waste overflows into the Hudson river.

In the UK, much of the blame has been levelled at privatised water companies, which are responsible for sanitation in

many regions. It is true that they have run up enormous debts while giving away billions to shareholders. They have also failed on many metrics, including poorly-maintained pipes. However, the real culprit is the government, which has failed to give water companies stringent enough targets or enforce those that have been set.

If firms profited while the environment suffered, it is because the government let them. Water and sanitation are public goods on which we all depend, so if private firms fail, governments ultimately have to step in. It is a pattern we have seen over and over, from banking crashes to nuclear power accidents. We can't deny the fact that some problems need strong political intervention – and stopping sewage overflows is one of them. ■

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Strange surges

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Hair-raising find

We are hopeless at telling when we have goosebumps **p11**

Let sleeping bees lie

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Original influencers

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Go with the flow

Swimming behind someone cuts drag by up to 40 per cent **p19**

Space

Winged messenger approaches the ISS

This is a Cygnus cargo craft, snapped from the International Space Station (ISS) on 4 August as it passed some 420 kilometres above the Red Sea coast in Saudi Arabia. The spacecraft, built by Northrop Grumman, has now docked at the ISS and delivered its cargo of science experiments. It will stay there until October, when it will depart to burn up on re-entry into Earth's atmosphere.



The superconductor free-for-all

People around the world are trying to verify if a material called LK-99 is a superconductor at room temperature and pressure. But it is no easy task, finds **Karmela Padavic-Callaghan**

WHEN researchers claimed recently that they had created a material that perfectly conducts electricity – a superconductor – and that it does so at room temperature and pressure, many people were sceptical.

Such a finding could radically increase the efficiency of many technologies, including magnetic levitation and nuclear fusion. So, labs and lone scientists around the world have kicked into action, racing to create and test the new material, called LK-99, to see if it really is what its creators claim. Some efforts are being reported in preprints published online, and some people are posting blow-by-blow accounts on social media, but their task is not an easy one.

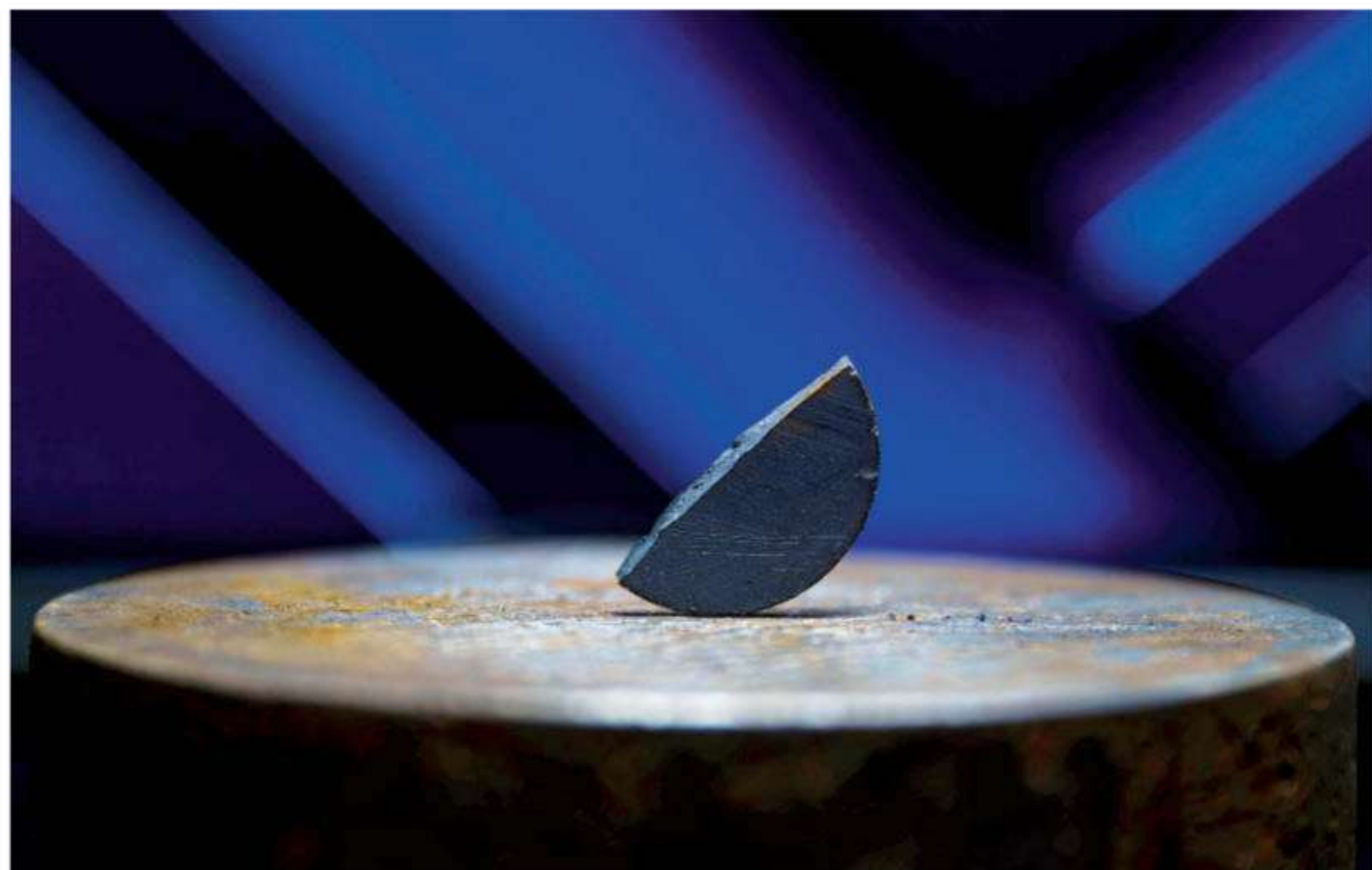
The evidence in favour of LK-99 superconducting at room temperature and pressure – initially presented by Hyun-Tak Kim at the College of William & Mary in Virginia and his colleagues, who created the material ([arXiv, doi.org/kk42](https://arxiv.org/doi/10.48550/arXiv.2208.15010)) – has left many people unconvinced.

Several independent research teams say they have now recreated LK-99 in their own labs. The first teams found no evidence that it is a superconductor at room temperature and pressure.

Step by step

“As of today, our answer is [that it is] not superconducting,” says V. P. S. Awana at the National Physical Laboratory of India, who led one of the teams.

He and his colleagues followed the steps for creating LK-99 outlined in papers that first introduced the material. They then used X-rays to confirm that the structure of what they had made was consistent with the original descriptions ([arXiv, doi.org/knks](https://arxiv.org/doi/10.48550/arXiv.2208.15010)).



ROKAS TENYSALAWY

LK-99's creators claim it is a superconductor at room temperature and pressure

To test the superconductivity of their version of LK-99, the researchers measured its electrical resistance and how it reacted to magnetic fields, again mirroring the work of Kim's team. The results didn't indicate superconductivity.

Another replication attempt, carried out by Zhiqi Liu at Beihang University in China and his colleagues, followed a similar procedure and also didn't find the material to have the extraordinary properties it was claimed to have ([arXiv, doi.org/knkt](https://arxiv.org/doi/10.48550/arXiv.2208.15010)).

Why are people finding the results tough to replicate?

“When superconductivity is claimed in materials where nobody expected it, the very first thing that must be shown is zero resistivity,” says Sankar Das Sarma at the University of Maryland.

Measurements of resistivity must be done very precisely, making sure that an apparent zero measurement isn't a quirk of laboratory equipment or the result of a misinterpreted reading. Currently, four teams have measured the resistivity of LK-99, but only two have found signs of zero resistivity.

Kim and his colleagues originally reported a drop to zero resistivity for temperatures

“When superconductivity is claimed, the very first thing that must be shown is zero resistivity”

ranging from 30°C (86°F) to 127°C (261°F). A team led by Zhixiang Shi at the University of Nanjing in China found it only dropped to zero at temperatures below -163°C (-261°F).

In both cases, many commentators said that the drop wasn't actually to zero

but rather to values that seemed close to zero only when compared with the material's resistivity at higher temperatures.

There are other properties that a true superconductor should exhibit, such as being able to levitate above a magnet.

Several videos, including from the engineer Andrew McCalip, who has been experimenting in his spare time, and Haixin Chang and his colleagues at Hangzhou University of Science and Technology in China, have shown samples of LK-99 partially floating above magnets.

But published measurements of how strong this magnetic effect is are sparse, so it isn't yet clear whether this levitation can only be due to superconductivity, or an unrelated magnetic phenomena.

There are other ways to test a superconductor, such as checking if it responds to heat in a particular way, which is evaluated using a measure called heat capacity.

A superconductor should also have restrictions on what energy levels its electrons can inhabit. Comparable measurements of these properties have yet to be publicly reported.

Electron properties

To get a picture of what is going on despite this data gap, researchers have been trying to figure out what the electrons inside LK-99 could be doing to give the material special properties.

Sinéad Griffin at the Lawrence Berkeley National Laboratory in California has used computer simulations to calculate the energies and momenta of electrons in LK-99 based on the arrangement of the compound's atoms (arXiv, doi.org/kmwt).

Her computations revealed that some electrons may have properties like those in some other, more established superconductors. However, these properties could also be caused by other phenomena like exotic magnetism, says Griffin. "Superconductivity is an option, but it is not a guarantee," she says.

Teams led by Daniel Dessau at the University of Colorado Boulder (arXiv, doi.org/knkv) and Xing-Qiu Chen at the Chinese Academy of Sciences (*Journal of Materials Science & Technology*, doi.org/knkw), as well as Karsten Held at the Vienna Institute of Technology in Austria and Liang Si at Northwest University in China, have also independently carried out similar computations and found the same electronic properties as Griffin, thus bolstering the claim that even if LK-99 is not a miracle superconductor, it is at least unusual for its class of materials.

Jose Pizarro at the Humboldt University of Berlin in Germany

says these calculations imply that LK-99, as simulated, has some surprising and promising electronic properties.

Calculations that would prove superconductivity more definitively are still missing, but Griffin's work is a first and necessary step towards discerning what exotic phenomena, like superconductivity but also certain types of magnetism, could be at play here, says Pizarro.

However, some of the assumptions that went into the calculations may not fully represent the material tested by Kim's team, says Leslie Schoop at Princeton University. That is

"Superconductivity is an option for what's causing the strange effects, but it is not a guarantee"

because the original analysis of how LK-99's atoms were arranged was "not up to community standards", she says. Other chemists have similarly described the way Kim's team analysed X-ray data to establish

this arrangement as imprecise.

Discrepancies in results are likely to come down to the purity and exact make-up of the samples of LK-99 that have been created, but assessing this isn't easy.

All the new samples of LK-99 have been made according to Kim's team's procedure but have relied on X-rays to verify the arrangement of atoms in the material.

"It's not clear that we know what has been made," says Christopher Hendon at the University of Oregon. X-ray imaging only reveals arrangements of atoms within crystalline materials, but the procedure for making LK-99 may also result in some compounds that aren't crystalline and would hence not be "seen" by X-rays, he says. In fact, some of the earliest reports about the creation of LK-99 noted that only about 50 per cent of each sample was the new material.

Robert Palgrave at University College London says the way that the X-ray data comparisons have been done isn't ideal either. It is like they "held up the two things,

and they looked at one and look to the other and were like, 'yeah, that's the same'", he says.

In his view, replication efforts have not made a strong case that they are testing the same compounds.

Both Hendon and Palgrave are calling for a detailed analysis of all the chemical elements present in the samples, as well as for more rigorous analyses of the X-ray data.

Hunt the atom

Griffin says that one sticking point from her computations is that copper atoms inside LK-99 must be in just the right place to support the special electronic properties that her computations revealed, yet that configuration isn't necessarily the most likely outcome if someone is making the material.

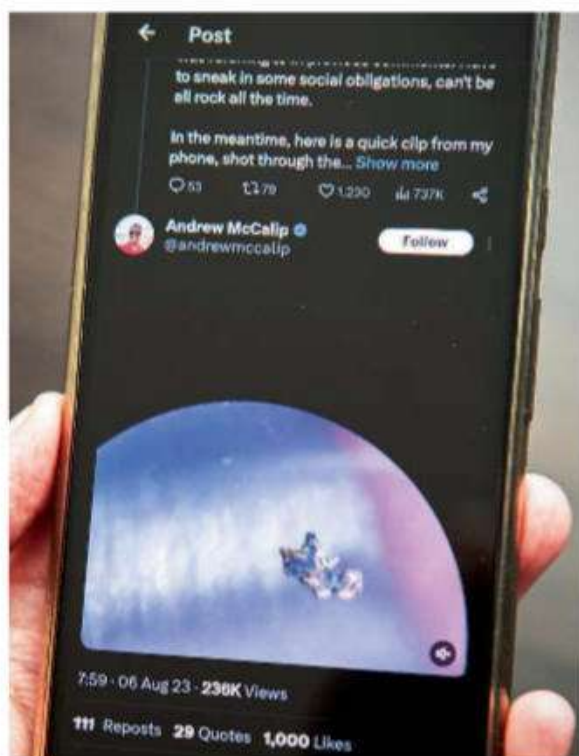
"I have lots of colleagues that are trying to make this thing and that's a useful piece of information for them," she says.

For Kim, videos of magnetic levitation show that the "replication problem disappeared". He blames cases of non-levitating LK-99 samples, like those reported by the teams in India and China, on their poor quality. Researchers are now in a "competition era" to make more high-quality samples, he says.

For Awana and his team, improving the quality of their samples is crucial.

"More trials are under way to get better-quality LK-99 and to reproduce its reported superconductivity," he says. "Having been a player in the field of superconducting materials for over 35 years, I believe this is possible and that LK-99 is to date the most promising case for room-temperature ambient-pressure superconductivity." ■

Many of the attempts to replicate the proposed superconductor LK-99 have played out on social media



TIM BODDY

Space

Inexplicably bright light is coming out of the sun

Leah Crane

ASTRONOMERS have detected gamma rays being emitted by the sun that are more energetic than expected.

Many of the gamma rays we see coming from the sun are produced by cosmic rays – charged particles that hurtle through space. When cosmic rays hit the sun, the magnetic fields there can blast them towards Earth, but in the process, they collide with the particles in the sun's atmosphere, creating gamma rays.

We knew that the sun produces some gamma rays with energies higher than expected, but now Mehr Un Nisa at Michigan State University and her colleagues have used more than six years of observations from the High-Altitude Water Cherenkov observatory in Mexico to show that some gamma rays are in the teraelectronvolt range. This is similar to the energy of particles smashed together at the Large Hadron Collider (*Physical Review Letters*, doi.org/km76).

"This is completely unprecedented," says Nisa. "This light is a trillion times more energetic than the light from a normal light bulb."

"This is unprecedented. This light is a trillion times more energetic than the light from a light bulb"

Light at such high energies is difficult to produce, especially since the sun's magnetic field is expected to repel cosmic rays with very high energies. "Given what we know about the sun's atmosphere, how dense it is, what those magnetic fields are like, the numbers don't add up," says Nisa. There are exotic ideas involving dark matter being captured in the sun that could lead to gamma rays, but for now how the sun is producing this high-energy light remains a mystery. ■

Climate change

Death Valley flower may hold secret to plant heat adaptation

Alice Klein



KRZYSZTOF ZIARNEK, KENPAZ/WIKIMEDIA COMMONS

A FLOWERING shrub in California's Death Valley is one of the most heat-tolerant plants known and could hold clues for engineering crops that can cope with rising temperatures.

Most agricultural crops can't withstand temperatures above 35°C (95°F), meaning our food sources could be affected as climate change worsens.

Seung Rhee at Michigan State University and her colleagues wondered whether crops could be made more heat-resilient by incorporating traits from those that thrive in hot conditions.

They concentrated on a plant called *Tidestromia oblongifolia* that appears to flourish in the desert of California's Death Valley. Death Valley is where the hottest-recorded temperature on Earth – 56.7°C (134°F) – was measured in 1913, and it reached 53.3°C (127.9°F) there last month. "When I heard about this plant, I thought, 'Wow, that's amazing, I can't imagine any organism being able to survive under those conditions, let alone thrive,'" says Rhee.

She and her colleagues studied the plant by growing it in a chamber in their lab at

moderate temperatures and in conditions mimicking summer in Death Valley. As a comparison, they also grew a related plant that is native to Mexico called *Amaranthus hypochondriacus*.

Under the Death Valley conditions, *A. hypochondriacus* ceased growing within a few days, but *T. oblongifolia* flourished, tripling its biomass in 10 days. Even at 50°C (122°F), the upper limit of the chamber, *T. oblongifolia* still exhibited effective photosynthesis. The researchers have built a new chamber that can be ramped up to 60°C (140°F) to see how far they can push the plant.

A closer look revealed some of the tricks *T. oblongifolia* deploys to cope with extreme heat. For example, its leaf cells became smaller, increasing the density of its chloroplasts, where photosynthesis occurs. And many of the leaves' mitochondria, which provide energy, moved closer to the chloroplasts (bioRxiv, doi.org/knp9). Together, these processes may have increased the plant's ability to photosynthesise in the harsh conditions, says Rhee.



The shrub *Tidestromia oblongifolia*, found in Death Valley, California, grows quickly when temperatures hit 50°C (120°F)

Similarly, under increasing heat, the plant's chloroplasts morphed from a standard disc shape into a cup shape. This may have let them hold on to carbon dioxide and prevent leakages more effectively while they were carrying out photosynthesis, in which CO₂ is converted to sugars, says Rhee.

The researchers also identified thousands of genes in the plant that increased or decreased in expression as temperatures rose. The team is now trying to pinpoint the most important genes responsible for the plant's heat tolerance in the hope of transferring them to agricultural crops.

Brian Atwell at Macquarie University in Sydney, Australia, and his colleagues have already shown that a conventional short-grain rice variety can be made more heat-tolerant by inserting a gene they discovered in a species of Australian wild rice called *Oryza australiensis*. This opens up the possibility of making other crops more resilient by transferring genes from *O. australiensis*, *T. oblongifolia* or other heat-loving plants, says Atwell. ■

We can't tell if we have goosebumps

People seem to incorrectly report when piloerection makes their hairs stand on end

Michael Le Page

YOU might think you know when something has made your hair stand on end, but a study shows we generally can't tell whether or not we have goosebumps, or where on our body they are.

Jonathon McPhetres at Durham University, UK, and his colleagues have been studying goosebumps for the past few years. "There's very, very little research on them and it's just fascinating because it's one of those things that we're so familiar with," says McPhetres. "One of the things that we noticed was that people are self-reporting goosebumps and we're also watching goosebumps objectively on the camera, and they just don't match."

So the researchers filmed the thighs of 50 volunteers as they watched videos that give most people goosebumps. While expressions such as "it made my hairs stand on end" or "it gave me goosebumps" are often used

figuratively, the participants were asked to press a button when they thought they had goosebumps and hairs standing on end, known as piloerection, as opposed to merely feeling "chills" or other emotional responses.

The volunteers were seated at a desk, so were able to look at their arms to see if they had

"It probably takes a level of acuity we don't have to distinguish between chills and actual goosebumps"

goosebumps, but it was hard for them to see their legs. The team found that, in most cases, those with goosebumps that were visible on camera weren't pressing the button, and vice versa.

In case the participants were getting goosebumps on, say, their thighs but not their arms, the researchers added another

three cameras to monitor their arms and calves as well. They then tested another 40 volunteers, but the extra cameras made hardly any difference to the results.

Overall, nearly 60 per cent of the total 90 volunteers did get piloerection and 50 per cent reported getting it, but only in a third of cases did the observed piloerection correspond with the participants' reports.

Only 16 per cent of the volunteers did any better than would be expected when guessing, and not by much. "The highest levels of accuracy were still not very accurate," says McPhetres.

In a follow-up online survey, an additional 500 people were asked where they get goosebumps when they get them. More than 40 per cent said on their forearms, yet the tests with many cameras showed that goosebumps appear at the same time on the arms and legs,

rather than just on one specific site (bioRxiv, doi.org/knkz).

Our ability to know if we have piloerection is an example of what is known as interoceptive awareness. Other studies have linked poor awareness of what is happening physically to the body to poor mental health.

"People are just not very good at distinguishing between different physiological sensations," says McPhetres. "It probably takes a level of acuity that we don't possess to distinguish between chills and actual goosebumps."

Many mammal species use piloerection to protect themselves from the cold and to make themselves look bigger when threatened, such as cats raising their hackles. In people, it is no longer thought to have such an important role. However, McPhetres says he has found that piloerection still raises skin temperature in humans. ■

Space

NASA misplaces Voyager 2 then finds it again a week later

NASA has reestablished full communication with the Voyager 2 spacecraft after losing touch with it in late July. The space agency has confirmed that the craft, which is nearly 20 billion kilometres away from Earth, is operating normally.

Voyager 2 launched in 1977 and has been hurtling towards the outer edges of the solar system and into interstellar space since then. It is now the second-most distant spacecraft from Earth after its sibling craft, Voyager 1, which is almost 24 billion kilometres away. Several of its science instruments, including its magnetometer and its

cosmic ray detector, are still working 46 years after launch and sending data back to Earth.

On 21 July, a series of commands from mission control inadvertently shifted the orientation of the spacecraft, pointing its antenna just 2 degrees away from Earth. That meant that the signals from the probe weren't reaching satellite dishes on the ground, and operators couldn't send any signals to try to turn it back towards us.

Thankfully, on 31 July, NASA detected a faint hint of what is called a "carrier signal" from Voyager 2. "We see the 'heartbeat' signal from the spacecraft... so we know the spacecraft is alive and operating," Suzanne Dodd, the manager of the Voyager project at NASA's Jet Propulsion Laboratory



NASA/JPL

An artist's impression of NASA's Voyager spacecraft

enough to extract anything from it.

In an attempt to point the antenna back towards Earth, NASA's Deep Space Network facility in Australia sent a new command to Voyager 2 to reorient itself. "There is a low probability that this will work," Dodd said at the time. It took 18.5 hours for the "interstellar 'shout'" to reach the craft and another 18.5 hours to receive the response, which came in on 4 August, NASA announced in a press release. Voyager 2 began sending telemetry data, showing that it was operating normally and on its expected trajectory. ■

Leah Crane

in California, told *New Scientist*.

Generally, if the antenna was aligned properly, this signal would contain real-time data from the spacecraft, but because it wasn't aligned, the signal wasn't strong

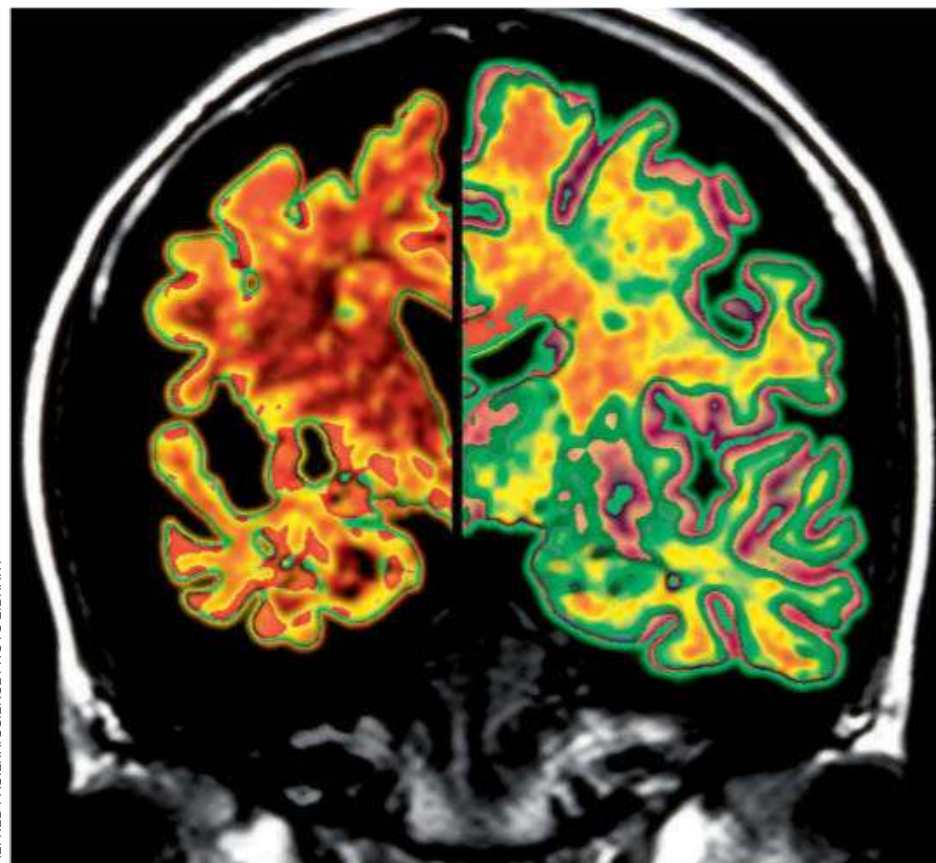
Why consumer tests for risk of Alzheimer's have potential downsides People in the US can now order a blood check online to pick up warning signs of Alzheimer's, but it is unclear what they can do about it if they are told they are at risk, says **Clare Wilson**

A BLOOD test that indicates if someone is at high risk of developing Alzheimer's disease went on sale to the public in the US on 31 July. It could give people an early warning about deteriorating health, perhaps allowing them to take preventative measures, says the manufacturer, Quest Diagnostics. But some doctors are urging caution, saying the science is too uncertain and a positive result could cause distress for no real benefit.

The test is based on a protein called amyloid, which is thought to build up in the brain over many years before people see symptoms of Alzheimer's, such as memory loss and confusion. In the past couple of years, two drugs consisting of antibodies that bind to amyloid have shown promise in slowing the deterioration seen with the condition – although the impact is small and there are concerns about side effects.

Researchers have long investigated whether amyloid levels could also give clues about disease progression. People can't receive the antibody treatments unless they have a brain scan that shows amyloid clumps, known as plaques, or a test of their spinal fluid that shows excess amyloid. More recently, several firms including Quest have begun offering blood tests for amyloid to doctors. A common version measures the ratio of one form of the protein to another, with a low number indicating more brain plaques. The ratio tends to fall below a certain amount about six years before plaques in the brain reach concerning levels, independent research suggests.

Quest is the first firm to let members of the public order the test themselves. In theory, they can only do this if they are at a higher risk of Alzheimer's and under the



Brain scans showing effects of Alzheimer's (left) compared with an unaffected brain (right)

Blood tests can detect an Alzheimer's-related protein called amyloid



diagnosis. There are few details available yet on how informative this test is for people who have no Alzheimer's symptoms.

When contacted by *New Scientist*, Quest provided a summary of a conference presentation about the test's accuracy. The firm says that fuller results will eventually

"It would be concerning if people were potentially left alone with a frightening result"

be published in a peer-reviewed journal. But, for now, we don't know what proportion of people with a positive result and no symptoms end up being diagnosed with Alzheimer's in five or 10 years' time, simply because these tests haven't been around long enough. "We don't know how meaningful these results are to someone without overt cognitive impairment," says Thambisetty.

It is also likely that a positive result would be a psychological blow – and there is little that people could do to act on the results. In its press release announcing the test, Quest said that interventions to stall or mitigate Alzheimer's may be most effective when begun in the early stages of the condition. But the new amyloid-based drugs can't be given to people who have no cognitive impairment.

Quest also says people can adopt a healthier lifestyle to reduce their risk of progressing to dementia, for instance by starting a new exercise regime. It is true that exercise is recommended as a preventative measure by many medical bodies. But any benefit is likely to be small, because aspects of lifestyle – including diet, smoking status, exercise and other factors – have been calculated to

oversight of an online doctor, but in practice the tests can be bought by anyone aged 65 or over or anyone above 18 who ticks a box saying they have had symptoms, have a family history of Alzheimer's or have ever had a head injury. Realistically, anyone who wants to pay \$399 for the test can take it, says Madhav Thambisetty, a neurologist at the National Institutes of Health in Maryland.

When asked if this was the case, a Quest spokesperson said: "Our website at questhealth.com explains that the test is not a diagnostic test and that it is for individuals who meet certain criteria, such as family history of AD, experiencing mild cognitive impairment or past head trauma or injury."

The dilemma is what people do if they get a positive result. When doctors such as Thambisetty order the test, they do so for people who already have symptoms and the result is considered alongside other investigations to help guide

Is fusion energy finally here?

The US National Ignition Facility has produced a fusion reaction with a net gain in energy. What does that mean, asks **Matthew Sparkes**

contribute only 40 per cent of people's total risk of developing dementia. No randomised trial has yet shown that people with a positive amyloid blood test who adopt healthier habits can delay disease progression.

There are other concerns. In the US, people who get a positive result may find that it makes it harder for them to get health or life insurance. Prospective employers could also find out about the results, potentially putting them off hiring someone.

Of course, the same is true for all medical tests that indicate someone has a serious health condition, but in those other cases, a positive test result has the benefit that, once forewarned, people can receive treatment.

Quest says it has no plans yet to launch this test outside the US, but research teams globally are developing similar blood tests for Alzheimer's. For instance, a group of UK medical charities recently announced new funding for such research in a project called the Blood Biomarker Challenge.

"We do want to see blood tests that can be used in the clinic to help diagnose Alzheimer's disease," says Siân Gregory at the UK's Alzheimer's Society. She adds, however: "It would be concerning if people could access blood tests that identify them as high risk of Alzheimer's disease at home, and then be potentially left alone with a frightening result." Quest says it will put people in touch with a doctor to discuss the results and a doctor will proactively contact anyone who gets a positive result.

Research into amyloid levels is promising, but uncertainties remain, says Thambisetty. "How are people going to be able to handle those results? How will people alter their behaviour? I'm not sure we have the answers." ■

A BREAKTHROUGH fusion experiment has produced a net gain in energy for only the second time ever and with improved performance over the first successful attempt. Here is what the result really means.

What's so good about fusion?

Today's nuclear power plants rely on fission reactions, where atoms are smashed apart to release energy and smaller particles. Fusion works differently, by squeezing smaller particles together into larger atoms – the same process that operates within our sun. A nuclear fusion power plant could create more energy, with no radioactive waste, but containing and controlling such a reaction has been proving a monumental problem for physicists and engineers.

But we are making progress?

In December 2022, researchers at the Lawrence Livermore National Laboratory (LLNL) in California reached a historic

The National Ignition Facility uses lasers to control fusion experiments

milestone: they got more energy out of a fusion reaction than they put in. The lab's National Ignition Facility (NIF) fusion reactor used lasers to create enough heat and pressure to turn deuterium and tritium – isotopes of hydrogen – into a plasma in which fusion could occur. These lasers output 2.1 megajoules of energy, but the reactor produced about 2.5 megajoules, roughly a 20 per cent increase. While those numbers are nowhere near the

"One thing is clear: we can't rely on fusion energy to solve the climate crisis"

sort of ratio you would need to run a commercial reactor, it offered a glimmer of hope that fusion reactors were viable.

Now, the lab has reportedly created a second ignition – the term for a reaction that surpasses break-even – with the reactor producing around 3.5 megajoules, according to the *Financial Times*.

"In an experiment conducted on 30 July, we repeated ignition at NIF. Analysis of those

results is under way," a LLNL spokesperson told *New Scientist*, adding that the results will be reported in full at scientific conferences and in peer-reviewed publications.

Has fusion power been solved?

No. One problem is that while the reactor's output is higher than the laser's output, the lasers are inefficient. To create 2.1 megajoules of energy, they draw 500 trillion watts, which is more power than the output of the entire US national grid. So a challenge for the future is to create a reaction that dwarfs its total energy requirements, and not just the final laser stage.

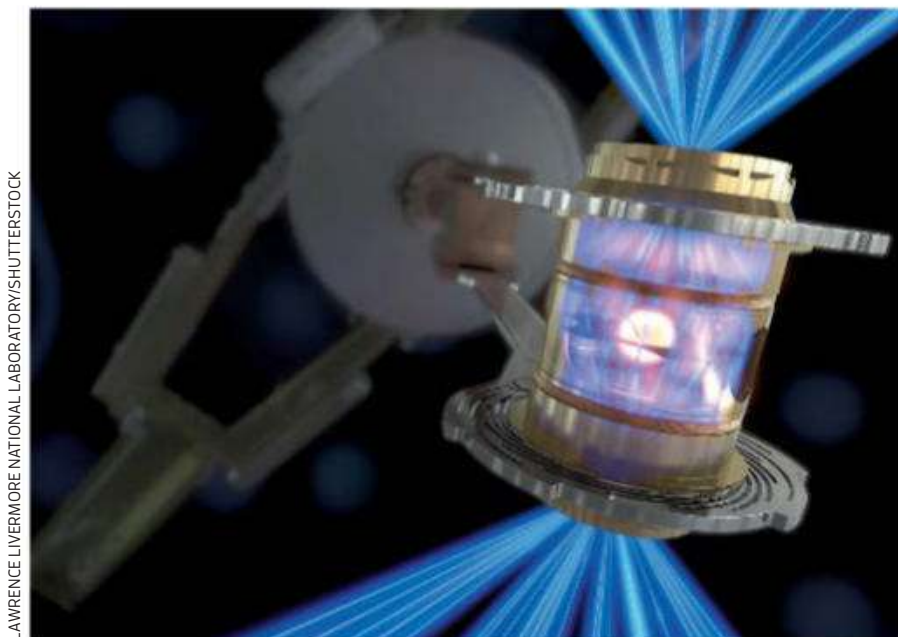
Another issue is that the NIF reactor can fire only once, for a few billionths of a second, before it has to cool down. A commercial reactor would have to run nearly continuously with multiple ignitions a second.

Will fusion ever be solved?

There could still be insurmountable problems ahead, but there is more cause for optimism than ever before. The science is sound, and the problem is now one of engineering rather than physics.

There are two main research approaches aiming to achieve viable nuclear fusion: using magnetic fields to contain a plasma, or using lasers, and a host of start-ups are working on unusual designs that will help us understand the problem and the best way forward.

But one thing is clear: a working fusion reactor is still years away and we can't rely on the technology to solve the climate crisis. Abundant clean energy will have to come from renewable sources in the short and medium term. ■



LAWRENCE LIVERMORE NATIONAL LABORATORY/SHUTTERSTOCK

ADHD linked to brain signals

Disrupted brain signals have been tied to attention deficit hyperactivity disorder in adults

Jason Arunn Murugesu

ATTENTION deficit hyperactivity disorder (ADHD) may be caused by disruption to brain signals that are involved in cognitive control. A link between this disruption and ADHD was previously made in children and has now been shown in young adults, improving our understanding of what could be behind the condition.

ADHD affects behaviour, with symptoms including hyperactivity, inattention and hyperfocus. Gráinne McLoughlin at King's College London and her team have previously shown that children with the condition experience disruption to the so-called frontal midline theta brain signals in their prefrontal cortices. These signals can be used as a measure of someone's degree of cognitive control, which helps them stay on task when potential distractions are present, says McLoughlin.

She and a different team of colleagues wanted to find out if this disrupted brain signalling also occurred in adults with ADHD, so they did electroencephalogram scans of the brains of 283 pairs of identical twins, aged between 21 and 23 years old, as they were put through cognitive tests.

The participants are part of a long-running twin study and have been monitored since birth, giving the researchers behavioural data going back to their childhoods. By studying identical twins, the researchers hoped to estimate how much of any disrupted brain signalling could be attributed to genetic variations.

Of the 566 participants, 111 adults met the criteria for ADHD, as diagnosed by the researchers via a standard test. In some twin pairs, both qualified for such a diagnosis, while in others only one

person or no one was diagnosed.

The people that the researchers diagnosed with ADHD were more likely to have these disrupted brain signals than those they hadn't diagnosed, mirroring the finding previously made in children. The adults who had this disrupted signalling were

"ADHD symptoms in childhood can help predict someone's brain function later in life"

also more likely to have shown ADHD symptoms when they were children. "ADHD symptoms in childhood predict brain function later in life," says McLoughlin.

The team identified a genetic overlap between having ADHD symptoms as a child and being diagnosed with the condition as an adult (*Biological Psychiatry*,

doi.org/knj5). However, the relatively small study doesn't show how widespread this disrupted brain signal is in people with ADHD, nor does it reveal whether it is the condition's cause. "It could be the case that the same genes cause [disrupted] midline theta frontal signals and cause ADHD but they're not causally related," says McLoughlin. Nevertheless, if a link is confirmed by more studies, reducing the variability in this disrupted brain signal could help to treat ADHD, she says.

Dianne Newbury at Oxford Brookes University, UK, says it is unlikely that just one factor causes ADHD, but "links between these factors can help us to start to understand differences between individuals and allow us to target specific processes and pathways that contribute to these differences". ■

Palaeontology

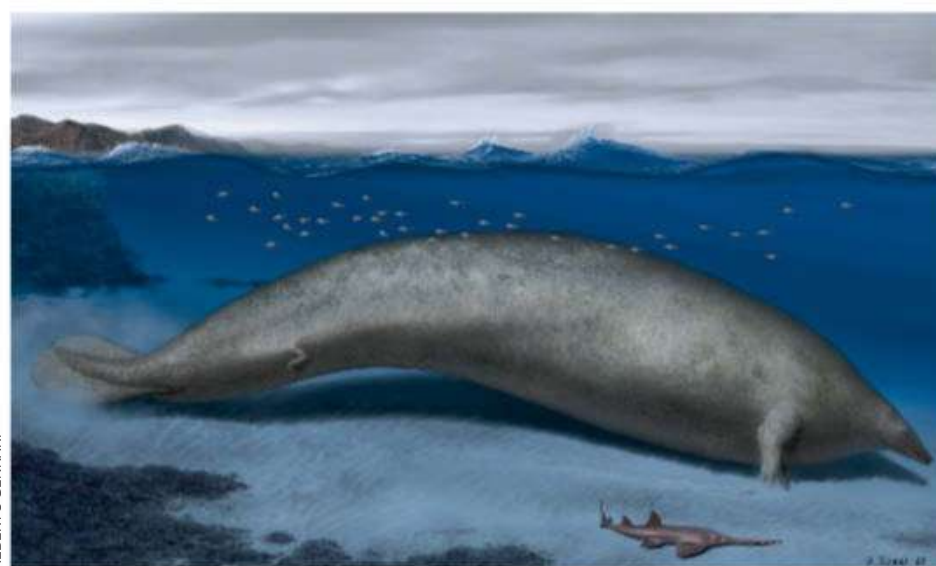
Ancient whale might have been heaviest animal to ever live

AN ENORMOUS species of ancient whale, whose fossils have been discovered in Peru, was one of the heaviest animals that ever lived.

In 2010, palaeontologists in southern Peru stumbled across a strange object. "It was so weird that the scientists were not even sure it was actually bone," says Eli Amson at the State Museum of Natural History Stuttgart in Germany.

It was only during its excavation that they realised the object must have been the bone of an enormous cetacean, a type of aquatic mammal that includes whales and dolphins.

Amson and his colleagues have since unearthed more bones, piecing together a partial skeleton



ALBERTO GENNARI

consisting of four ribs, 13 vertebrae and a small, broken pelvic bone. From carbon dating of the surrounding sediment, the team estimates the specimen is around 39 million years old.

The researchers reconstructed what the whole skeleton might have

looked like by comparing the bones with those of similar species from that time. They determined that the fossil belonged to a new species of whale, which they named *Perucetus colossus*. Based on the closely related ancient whale *Cynthiacetus peruvianus*, they suggest it had a

Reconstruction of *Perucetus colossus*, a whale that lived some 39 million years ago

small head relative to its body.

From the model, the team estimates *P. colossus* was probably about 20 metres long and weighed between 85 and 340 tonnes. The largest blue whale on record weighed 190 tonnes, so *P. colossus* is a contender for one of the heaviest animals to ever exist (*Nature*, doi.org/knj4). Without a skull, we can't tell what this animal would have eaten, though.

"Estimating body mass in fossils is always super difficult, but I don't think there is any doubt that this whale was very large," says Lars Schmitz at Claremont McKenna College in California. "What a remarkable find!" ■

Chen Ly

Neuron-like machinery helps anemones know when to sting

Sofia Quaglia

A PROTEIN similar to one found in human neurons allows anemones to choose when and who to sting. Understanding how this protein guides stinging decisions shows how even the tiniest, subtlest adaptations can drastically change an organism's behaviour.

Anemones sting by shooting out venom-covered barbs called nematocysts, which can grow to 20 to 50 times their original size and travel at the speed of a fired bullet, says Nicholas Bellono at Harvard University.

"It's one of the fastest events in biology," he says. "It's very explosive."

The barbs can only be discharged once, and it takes a lot of energy to make them. As anemones lack a central nervous system, researchers have long been baffled by how the animals manage to avoid wasting their weapons.

Bellono's team studied the pale anemone (*Exaiptasia diaphana*). These animals live in exposed ocean environments and don't hunt, but get nutrition by housing photosynthetic organisms in return for protection.

When the researchers probed the anemones' tentacles, the creatures indiscriminately shot out their microscopic bullets. Dissection of the tentacles revealed that the nematocytes – the cells that produce the barbs – have proteins called calcium ion channels similar to those in human neurons.

When activated, these channels permit the flow of calcium ions into neurons so that electrical signals can propagate. In the pale anemone, the channels are only weakly inactivated, meaning it is easier to set them off.



NATURE PHOTOGRAPHERS LTD/ALAMY

These channels work differently in the predatory starlet sea anemone (*Nematostella vectensis*), a burrowing anemone that keeps only its tentacles exposed, ready to sting passing prey. Its ion channels are inactivated much more strongly, meaning it takes a stronger stimulus to open them (*eLife*, doi.org/km75). In a previous study, these anemones were triggered to sting solely if they perceived specific prey chemicals in their environment as well as physical touch.

Even when the ion channels were cloned and placed into other cells – like frog eggs or human cells, which wouldn't normally have them – these differences persisted.

"That means that protein on its own intrinsically behaves this way, which is very strange," says Bellono. "It's really a nice example of evolutionary tuning of an existing protein that many other organisms use, which has just been subtly modified to

"That means that protein on its own intrinsically behaves this way, which is very strange"

The starlet sea anemone attacks prey if it detects touch and chemicals

control this decision process."

Bellono says these findings suggest a pattern: the nematocytes of predatory anemones tend to have inactive calcium ion channels, while those of defensive anemones tend to have active calcium ion channels.

"An ancient organism with a primitive nervous system is able to implement optimal decisions in a way that's ingrained in their molecular machinery," says team member Agnese Seminara at the University of Genoa in Italy. "This is very exciting because it's a principle and principles are rare in biology."

Greg J. Stephens at VU Amsterdam in the Netherlands says it may be hasty to conclude that one small protein makes a big difference in behaviour without understanding its context.

He says more research is needed, particularly in the wild, to strengthen the link between molecular machinery and behaviour. ■

AI voices hard to spot even if you know they may be fake

Jeremy Hsu

EVEN when people know they may be listening to speech generated by artificial intelligence, it is still difficult for English and Mandarin speakers to reliably detect a deepfake voice. That means billions of people are potentially at risk when exposed to deepfake scams or misinformation.

Kimberly Mai at University College London and her colleagues challenged more than 500 people to identify speech deepfakes among multiple audio clips. Some clips contained the authentic voice of a female speaker reading generic sentences in either English or Mandarin, while others were deepfakes created by generative AIs trained on female voices.

Study participants were randomly assigned to one of two experimental set-ups.

One group listened to 20 voice samples in their native language and had to decide whether the clips were real or fake. People correctly classified the deepfakes and the authentic voices about 70 per cent of the time for both the English and Mandarin voice samples.

A second group was given 20 randomly chosen pairs of audio clips. Each pair featured the same sentence spoken by a human and the deepfake, and participants were asked to flag the fake. This boosted detection accuracy to more than 85 per cent (*PLoS One*, doi.org/gsjtsb).

"This set-up is not completely representative of real-life scenarios," says Mai. "Listeners would not be told beforehand whether what they are listening to is real, and factors like the speaker's gender and age could affect detection performance."

Hany Farid at the University of California, Berkeley, says such research shows how good AI-generated deepfakes are now at mimicking human voices and provides a baseline for automated deepfake detection systems. ■

Chemistry

Chemical reaction used in cooking may have nurtured complex life

Carissa Wong

A CHEMICAL reaction that gives flavour to cooked food may lock away millions of tonnes of carbon in the seabed each year. The process might even have helped create the conditions for complex life to evolve.

The Maillard reaction occurs fast between sugars and amino acids when temperatures rise above roughly 140°C (284°F). This produces a range of complex, carbon-rich compounds, giving colour and flavour to foods such as seared meat, roasted vegetables and toasted bread.

Minerals containing manganese can act as a catalyst, enabling the reaction to occur quickly at temperatures as low as 25°C (77°F). To explore if this chemical process can happen effectively at even lower temperatures, where it was thought to happen too slowly to affect much, Caroline Peacock at the University of Leeds, UK, and her colleagues added manganese minerals to a solution containing the sugar glucose and the amino acid glycine. They also tried adding iron as a catalyst.

When the mixtures were incubated at 10°C (50°F) – roughly the temperature of the seabed at the edges of continents – the minerals sped up the Maillard reaction by around 100 times, compared with mixtures of sugar and amino acids without the catalysts.

Further analysis revealed that the process produced compounds found in marine sediment samples. This suggests the Maillard reaction occurs on the ocean floor, where iron and manganese minerals are commonly found, says Peacock.

On the seabed, dead plants and animals provide a source of sugars and amino acids that microbes ingest as a source of



RALPH HETTLER/GETTY IMAGES

energy. During this process, the microbes convert the carbon in dead organisms into carbon dioxide, which can re-enter the atmosphere.

If the Maillard reaction is happening on the ocean floor, this could cause the carbon found in sugars and amino acids to be stored in large, complex polymers that microbes find harder to ingest, says Peacock.

Over thousands or millions of years, these polymers would be buried deeper beneath the

4 million

Tonnes of carbon locked up per year thanks to Maillard reaction

sea floor as dead material accumulated on the seabed.

The researchers estimate that iron and manganese minerals may lock away roughly 4 million tonnes of carbon each year (*Nature*, doi.org/km7g). Without this process, Earth's atmosphere may have warmed by a further 5°C over the past 400 million years.

The Maillard reaction in marine sediments may have increased atmospheric oxygen

The Maillard reaction creates the brown crust on baguettes

levels by up to 8 per cent over the past 400 million years because burying carbon allows more oxygen to reach Earth's atmosphere, says Peacock.

"This process has such a profound impact on atmospheric oxygen," she says. "Because complex life forms require higher levels of oxygen, as they're more energetically demanding, we think it's reasonable to surmise this process had a hand in creating conditions required for complex life."

The work shows that the reaction can occur in soil that contains iron and manganese minerals, which suggests boosting the minerals in soil could help capture carbon from the atmosphere, says Peacock.

"This is a superb study," says Jan Amend at the University of Southern California. It highlights how iron and manganese chemistry can play a huge role in atmospheric chemistry and Earth's surface temperature, he says. ■

Zoology

Bees lose sleep if they are exposed to light at night

Jason Arunn Murugesu

HONEYBEES sleep less when exposed to artificial light at night, which could affect their ability to communicate and pollinate plants.

"Just like humans, honeybees need sleep," says James Nieh at the University of California, San Diego. For example, honeybees that haven't slept are less precise at performing the waggle dance – which tells other bees where to find nectar-rich flowers.

Honeybees don't sleep over a single period, but take naps during the day and night in their hives, where they are usually protected from light. However, bees can be exposed to artificial light at night if they are overheated in the hive and go outside to fan the entrance, says Nieh, or when a young queen flies off with a portion of the colony – a process known as swarming. "When bees are in a swarm, they can spend four to five days outside," he says.

Nieh and his colleagues put dozens of western honeybees (*Apis mellifera*) into two clear boxes, each with air holes and food. One box was illuminated for five days, the other was kept in darkness.

Whenever a bee was motionless for 5 minutes, the researchers recorded this as sleep. After 95 hours, bees exposed to constant light began to sleep less (BioRxiv, doi.org/km7f). Nieh says the findings suggest that bees are resilient to a few days' worth of constant light, but more than that could affect them negatively.

This could affect the ability of honeybees to pollinate plants, says Nieh. "About one in every five bites of food [eaten by humans] is due to insect pollination," he says.

Climate change may result in bees needing to cool their hives more often, increasing exposure to artificial light, says Nieh, so beekeepers should avoid putting hives near roadsides or where there are streetlights. ■

Physics

Why gold glows under light

Understanding the process may help us control the reactions used in energy storage

Karmela Padavic-Callaghan

WAFER-THIN gold flakes emit a faint glimmer after being hit with a laser, and now we are starting to understand why. This could give scientists more control over chemical reactions useful for energy storage and catalysis, where gold flakes are often used.

Gold owes its lustre to the way it reflects light. But ultra-thin gold flakes can also generate and emit light in a process called photoluminescence. When the gold is illuminated, some of the photons in the light are absorbed by the metal, and they trigger the gold to kick out new photons.

To investigate how this happens, Alan Bowman at the Swiss Federal Institute of Technology in Lausanne (EPFL) and his colleagues took flakes of gold that ranged in thickness from 13 to 113 nanometres. They illuminated the flakes with a powerful laser to make them photoluminesce and used a

detector to collect and analyse the photons that the gold released. Bowman says the equipment was so sensitive that it could detect the wavelength of the gold-emitted photons even when there were as few as one of them for every billion photons from the laser.

Using their measurements and computer simulations, the researchers put together a model for how photoluminescence occurs in gold flakes. They already knew the basic mechanics of the process: the energy from the incoming photon nudges an electron and a “hole” – a particle-like deficit of charge that behaves as the opposite of an electron – within the flake. This causes the electron and hole to combine and emit a photon. But their work revealed that there are multiple ways for this to happen.

Some of the holes that combine with electrons do so immediately, while some bounce around inside



MUSTAFA OZER/AFP VIA GETTY IMAGES

All that is gold doesn't glisten – sometimes it glows

the gold flake for a while first, says Bowman. The team also found that, for flakes more than about 40 nanometres thick, some of the properties of holes and electrons – like their energy and momentum – become more susceptible to quantum effects than was previously known (arXiv, doi.org/km68).

This new understanding could help people who want to use these electrons in devices like photovoltaic cells for solar panels.

Matthew Sheldon at Texas A&M University says understanding the photoluminescence process in gold flakes at this level of detail

could also advance the way researchers use tiny gold structures to concentrate and amplify energy from light to make better biosensors and to speed up chemical reactions, such as those used to produce fertilisers and fuels. “Nano structures made from gold are a workhorse platform in nanoscience,” he says.

“Electrons and holes in gold can pass lots of energy onto molecules, enhancing or altering

“Ultra-thin gold flakes can generate light in a process called photoluminescence”

some reactions,” says team member Giulia Tagliabue, also at EPFL. This would help people drive chemical transformations and monitor them with lasers, she says. She is hoping to use these particles to build novel light-rechargeable batteries. ■

Botany

Trees keep their distance to avoid pathogens

TROPICAL forests are often made up of a diverse range of trees, with large spaces between those of the same species, and it turns out this probably keeps them safer from attacks by pests, such as insects and fungal pathogens.

“Enemy species, like insect herbivores and fungal pathogens, are specialised to different tree species,” says Annette Ostling at the University of Texas at Austin. It is much easier for these to travel from one tree to another when the same type of trees are close together, she says. For example, insects can attack nearby seedlings of the same



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kind by dropping from a colony on a tree, while fungal pathogens can transmit to a neighbouring plant via water splashes.

To better understand how this affects tree distribution in tropical

forests on Barro Colorado Island, Panama, have been studied for decades

forests, Ostling and her colleagues studied 30 years' worth of data from a 50-hectare plot of tropical forest on Barro Colorado Island in the Panama Canal.

Using data on the location of every tree in this forest and how far the seeds of each species travel, Ostling and her colleagues produced a computer model of what the forest would look like if the trees had grown wherever seeds were most likely to land. They found that, in most cases, trees of the same species were three times as far apart in the real forest as their computer model predicted (Science, doi.org/km67).

The most likely explanation for this is enemy species, which probably also make tropical forests so diverse, says Ostling. Seeds that land close to the tree that they originated from are less likely to grow into a tree themselves as they are attacked by its enemy species, she says. Both distance and forest diversity would reduce chances of tree-specific pest transmission.

Enemy species may also help keep non-tropical forests diverse and widely spaced, but to a lesser extent, says Ostling. “The climate in tropical forests is more conducive to enemy species,” she says. “Without winters, insect populations can keep going all year around and hot weather is more conducive to fungal pathogens.” ■

Jason Arunn Murugesu

Health

Gut microbiome linked to fitness and biological age

Christoph Schwaiger

THE diversity of microbes in your gut could affect your fitness and biological age. Better understanding of this may one day lead to probiotics that alter the gut's microbial make-up to promote health.

Zsolt Radak at the Hungarian University of Sports Science and his colleagues have studied 80 amateur rowers, aged between 38 and 84, who participated in the 2019 World Rowing Masters Regatta in Velence, Hungary.

The rowers, whose training regimens ranged from practising every day to once a week, each provided a stool sample to identify the bacteria in their guts. The researchers also took blood samples to gauge the participants' biological ages – a measure based on DNA markers, rather than the number of years someone has been alive.

To assess fitness, the rowers completed various tests of things like their hand grip strength and maximum oxygen uptake, a measure of cardiovascular fitness.

Radak and his colleagues found that having higher levels of gut microbiome diversity was linked to lower levels of fitness and an accelerated rate of biological ageing. This somewhat goes against previous research that has linked lower gut microbial diversity to conditions such as obesity and type 2 diabetes.

"If all the bacteria were beneficial, then OK, it's very simple to say, 'the more diversity, the better,'" says Radak. "But with different

kinds of infections, the diversity of the pathogens also increases. There are a number of bacteria whose function is still poorly understood."

When analysing the specific bacteria that made up the rowers' microbiomes, the researchers found that higher levels of anti-inflammatory bacteria were associated with increased markers of fitness

"Higher levels of anti-inflammatory bacteria were associated with increased fitness"

and a reduced rate of biological ageing, while inflammatory bacteria were linked to an acceleration of this ageing and, in some cases, a worse performance on fitness tests.

The study was observational and therefore doesn't show that the gut microbiome directly affects a person's fitness or biological age. The people with a higher level of fitness may also be eating a healthier diet, which would then influence their gut microbiome.

The researchers also broke down the results according to the rowers' sex: 35 were male and 45 were female. There were no transgender participants. Higher levels of *Actinobacteria* and *Proteobacteria* species were linked to an acceleration of biological ageing among the male participants, while more *Bacteroidetes* species was associated with this for the female participants (medRxiv, doi.org/km65).

Better understanding the role of the gut microbiome in fitness and ageing could lead to people being able to take probiotics that change their bacteria levels to delay the biological ageing process, says Radak.

The study recorded just a snapshot of the participants' stools, blood samples and fitness, says Joseph Borg at the University of Malta. He says future research that investigates how things change over a longer period of time could shed more light on any relationship between the gut microbiome, biological ageing and fitness. ■



OLEKSANDRA TROJAN/GETTY IMAGES

Microbes in the gut are increasingly being linked to aspects of health

Technology

Concrete could work as battery for solar-powered homes

Jeremy Hsu

A MIXTURE of cement and charcoal powder could enable houses to store a full day's worth of energy from renewable sources in their concrete foundations. This new way of creating a supercapacitor – an alternative to batteries that can discharge energy faster – could be incorporated into the foundations of buildings and wind turbines.

"The materials are available for everyone all over the place, all over the world," says Franz-Josef Ulm at the Massachusetts Institute of Technology. "Which means we don't have the same restriction as with batteries."

Ulm and his colleagues showed how cement and carbon black – a very fine version of charcoal – can mix with water to create a hardened block containing many branching, wire-like structures filled with the carbon. When the concrete is soaked in an electrolyte solution such as potassium chloride, the charged particles from the electrolyte settle on the carbon-wire structures to provide energy-storing potential.

The researchers turned two thin slabs of the material just 1 centimetre wide and 1 millimetre thick into a supercapacitor by separating them with a thin insulating layer. Connecting three of these supercapacitors produced the equivalent of a 3-volt battery capable of lighting up a small LED.

Ulm and his colleagues say a concrete block equivalent to a cube 3.5 metres on each side could store 10 kilowatt-hours of energy (PNAS, doi.org/km64). That is about a third of the average daily household electricity use in the US and about 1.25 times the average in the UK.

The material maintained its capabilities beyond 10,000 charging and discharging cycles, so, in theory, it could provide energy storage for a solar-powered home for more than 27 years. ■

Zoology

Moths make their own minty fragrance

MALE tobacco budworm moths collect perfume from flowers and emit it to make themselves more attractive to females.

Female moths release chemicals to lure males, but less was known about how males use scent. Coby Schal at North Carolina State University and his colleagues have found that male tobacco budworm moths (*Chloridea virescens*) collect methyl salicylate. The compound is found in the nectar of many plants and has a sweet, minty odour.

The researchers discovered that when males courted females, they released the methyl salicylate from hair-tipped appendages known as hair pencils, and their mating success dropped by about 30 per cent if their hair pencils were removed (*Current Biology*, doi.org/km5t). **Alice Klein**

Technology

Fake silk harvests water from air

ARTIFICIAL fibres that can collect moisture from the air, much like how spider silk gathers dew, could be used for large-scale water collection from fog.

Yongmei Zheng at Beihang University in China and her colleagues coated microfibre threads with hydrophilic, or water-loving, titanium dioxide to create bumps. The researchers then used high temperatures to crack the bumps and give them a helical shape. The helix creates a larger surface area for a water droplet to attach to and forms stronger bonds with it, which means each bump can carry 2000 times more water than the volume of the bump itself (*Advanced Functional Materials*, doi.org/km54).

Zheng says a device about 10 centimetres across could gather enough drinking water for one person. **Alex Wilkins**



ROBERT PREZIOSO/GETTY IMAGES

Physics

How to cut drag when racing in open water

SWIMMERS competing in lakes and waterways, such as in the triathlon at the Olympic Games, can dramatically reduce the drag they feel by taking the right position relative to other people.

Remi Carmigniani at École des Ponts ParisTech in France and his colleagues have experimented with an 80-metre-long water channel and two plastic mannequins that resembled swimmers with their arms held tight to their bodies. Each was equipped with a sensor for drag forces, or friction forces, between the mannequin and water. The researchers tried the mannequins in different configurations, including one behind the other and side by

side, then ran water through the channel and collected drag data.

From these measurements, and computer simulations, they found that a person can reduce drag on their body up to 40 per cent by swimming behind someone else. If they have to swim side by side with a competitor, doing so at the level of their rival's hip reduces drag by about 30 per cent. Carmigniani says that the latter effect comes from swimmers "surfing" the waves created by their neighbours. They also found that when swimming behind another person in a lane, it is better to leave some distance (*Physical Review Fluids*, in press).

Team member Baptiste Bolon, also at École des Ponts ParisTech, says athletes told them that staying exactly next to another swimmer or passing them at their side is tiring and difficult. That is consistent with what the study found, he says.

Jean-Claude Chatard at Jean Monnet University in France says the findings could be useful to athletes. **Karmela Padavic-Callaghan**

Really brief



CHRISTIAN MCCALL

Jellyfish swam half a billion years ago

A fossil found in Canada reveals jellyfish developed the swimming stage of their life cycle more than 500 million years ago. The ancient species (see artist's impression above) has been named *Burgessomedusa phasmiformis* (*Proceedings of the Royal Society B*, doi.org/km6x).

Lead exposure linked to crime

Higher exposure to lead in childhood is linked with a greater likelihood of criminality in later life, a review of 17 studies has found. However, whether the element causes the behaviour or is just associated with it is unknown (*PLoS Global Public Health*, doi.org/km6w).

Reflective film could stop cars getting hot

A thin material that mimics the vibrant blue wings of *Morpho* butterflies could be used to keep cars cooler. The film is designed to reflect rather than absorb light. A piece placed on a parked car in sunlight reached 42°C (108°F), whereas conventional blue paint hit 75°C (167°F) (*Optica*, doi.org/km63).

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The columnist

Mike Marshall on the settlement of the Tibetan plateau **p22**

Aperture

Striking photographs capture microscopic marvels **p24**

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Are AI advances all they are cracked up to be? **p26**

Culture

A harrowing journey to the remains of a tiny hominin **p28**

Culture columnist

Simon Ings on *Oppenheimer* and nuclear paranoia **p30**

Comment

A shot of reality

Weight-loss injections such as Wegovy will need to be for life, not just two years. Health services must face up to that, argues **Clare Wilson**

HEALTHCARE systems around the world are grappling with the arrival of a new kind of weight-loss treatment: injections based on the medicine semaglutide, which is branded as Wegovy or Ozempic.

The UK is among the first countries where semaglutide looks set to be made available for weight-loss treatment through a publicly funded health system. Unfortunately, many doctors think England's guidance body has made a misstep by recommending people be restricted to two years of use, even though the drug is meant to be taken long-term. Health systems in other countries are also debating how to respond to this unprecedented situation, and none has yet found a good answer.

The dilemma is that, for the first time, weight-loss drugs have been developed that are broadly safe and effective. But so many people need the treatment that no one can figure out how health systems will afford it. In countries such as the UK, US and Australia, about two-thirds of the adult population are overweight or obese.

Wegovy has so far gone on sale in only a few countries, including the US and Germany, but its launch seems imminent in the UK. And people in many countries have been using Ozempic, the version of semaglutide approved for treating type 2 diabetes, which also causes weight loss.

Policy on semaglutide in the UK is mainly up to the National Institute for Health and Care



SIMONE ROTELLA

Excellence (NICE), the cost-effectiveness body for medicines in England, whose decisions are usually also followed in Wales and Northern Ireland. In March, NICE said people in England in certain weight and health categories could have semaglutide through the National Health Service, but only for two years. A decision in Scotland has yet to be announced.

NICE says its recommendations will provide value for money for taxpayers and are in line with the manufacturer's evidence and the fact that UK weight-loss clinics generally only treat people for two years. The institute has said it will

review its decision if longer-term evidence becomes available, but as it stands, the current position is bizarre. Trials show that when people stop taking semaglutide, they put most of the weight they lost back on. This raises the prospect that Wegovy users will experience dramatic swings of weight loss and regain. NICE even proposed such people might then restart treatment with the drug. The consequences of such weight yo-yoing are likely to be dire.

People in other countries are similarly struggling with irrational funding policies. In the US, Medicare, the federal health

insurance system for people aged 65 and older, is legally prohibited from funding weight-loss treatments. The same goes for all public insurance schemes in Germany. Some people in the US with private health insurance can access the medicine, although they may have to contribute prohibitive sums as "copays". And as demand for Wegovy takes off, some insurers are tightening their eligibility rules, for instance by requiring that people first try cheaper, less-effective medicines.

The restrictions are irrational because weight-loss treatments will almost certainly reduce other healthcare costs, such as from joint-replacement surgery and treating heart attacks, strokes and type 2 diabetes. Those gains may take a few years to materialise, but the cost-benefit equation is likely to tip more in favour of the new weight-loss treatment as time passes. This is because drugs usually drop in price after their launch and as competitors enter the market. More potent treatments are also likely to arrive in the near future.

The advent of this new class of medicines is going to have big ramifications for healthcare systems, however they are funded. But health policy-makers must be prepared to play the long game. ■



Clare Wilson is a *New Scientist* reporter and author of the Health Check newsletter

Our Human Story

On the roof of the world The notion that the Tibetan plateau was only settled within the past 5000 or 10,000 years has been blown apart over the past two decades, finds **Michael Marshall**



Michael Marshall is a science writer based in Devon, UK. He writes *New Scientist's* monthly email newsletter Our Human Story, about human evolution. His book *The Genesis Quest* is about the origin of life on Earth and is now available in paperback.

Michael's week

What I'm reading

Robin Hobb's *Liveship Traders* fantasy series, in which ships aren't just personalised by their owners, they are actually sentient.

What I'm watching

Either the film with the explosion of pink or the film with the explosion.

What I'm working on

Another deep dive into the origins of life on Earth.

This column appears monthly. Up next week: Chanda Prescod-Weinstein

EARTH has plenty of places that are difficult to live in, but high altitudes pose a unique set of challenges. The air is thin, so it is harder to breathe and therefore tricky to move around or work. It is also cold and windy, which makes farming difficult.

On that basis, the Tibetan plateau is one of the hardest places to live permanently. With an average elevation of 4000 metres above sea level, it is cold and dry, and much of the landscape is grasslands or steppes, along with large areas of permafrost. Oxygen levels are about 40 per cent lower than at sea level.

All in all, it is understandable that archaeologists once believed the Tibetan plateau was one of the last places to be permanently settled by humans or other hominins. While hominins have been living in other parts of Asia for around 2 million years, the thinking was that they only settled the Tibetan plateau within the past 5000 or 10,000 years.

For a long time, all the archaeological finds from the Tibetan plateau were from the past few thousand years. Based on that, the notion was that modern humans only managed to permanently settle the higher steppes about 3600 years ago. However, it has been clear for the past 20 years that people were venturing up there long before.

In 2002, David Zhang and Sheng-Hua Li at the University of Hong Kong found human hand and footprints in travertine, a kind of limestone that forms around mineral springs, near the Quesang river. They also found the remains of a fireplace. All these traces were dated to about 20,000 years ago.

In 2012, another hearth was found in the Qinghai Lake area in the north-eastern region of the plateau. It was 14,300 years old.

The following year, stone tools were found at a third site called Xidatan 2. They were between 9200 and 6400 years old.

In 2014, a genetic study upended the whole story. Despite the low levels of oxygen in the air, Tibetans don't tend to experience hypoxia. One gene implicated in this is *EPAS1*, which is involved in the body's response to low oxygen. Tibetans have a modified version of this gene compared with people in nearby low-altitude regions.

Geneticists found that the Tibetan *EPAS1* wasn't present in any other studied human population – but it was found

“In 2019, researchers re-examined a jawbone found in a cave on the plateau, and found it came from a Denisovan”

in the genome of a Denisovan, an extinct group of hominins that lived in Asia within the past few hundred thousand years. Humans are known to have interbred with Denisovans, and it seems the modified *EPAS1* came to Tibetans from these hominins.

So did Denisovans have this mutation to help them cope with altitude? At the time, they were only known from one cave in Siberia, but the genetics hinted they might also have lived on the Tibetan plateau.

During the 2010s, a series of studies extended the evidence that people lived on the Tibetan plateau at several points in the past 20,000 years. A 2016 study of a site called XDW1 reported an ash layer and stone tools, dating from 11,200 years ago. The authors said it was the first evidence of human activity above 4000 metres above sea level in the Tibetan plateau.

The following year, at the Chusang site, about 4270 metres above sea level, human handprints and footprints were found. Researchers determined that the site was 7400 to 12,700 years old. Given the difficulty of accessing such a location, this suggested people were living there permanently rather than visiting.

In 2019, evidence finally emerged of Denisovans on the plateau. Researchers re-examined a jawbone found in 1980 in Baishiya Karst cave in the north-east of the plateau. Its shape didn't match that of modern humans, and proteins from its teeth revealed it belonged to a Denisovan. Radioisotope dating suggested it was at least 160,000 years old – the occupation history of the plateau had been extended by over 100,000 years.

In 2021, Zhang, now at Guangzhou University in China, and his team found more hand and footprints at the Quesang site. They were small, suggesting they were made by two children 169,000 to 226,000 years ago. The researchers described them as the earliest “parietal art” – art created on surfaces like walls. The key point is that people may have been living on the Tibetan plateau for over 200,000 years, not 3600 or even 20,000 as we thought a few years ago.

Finally, we see that they kept coming back to the same places. In July, Zhang and his team published another study of the Quesang travertine. They found five handprints and 17 footprints, dated to various points between 6200 and 9200 years ago. Their interpretation is that the hot springs in the region were always attractive to hominins, perhaps as a buffer against the frigid climate. On the roof of the world, people turned to warmth from Earth's interior to help them survive. ■

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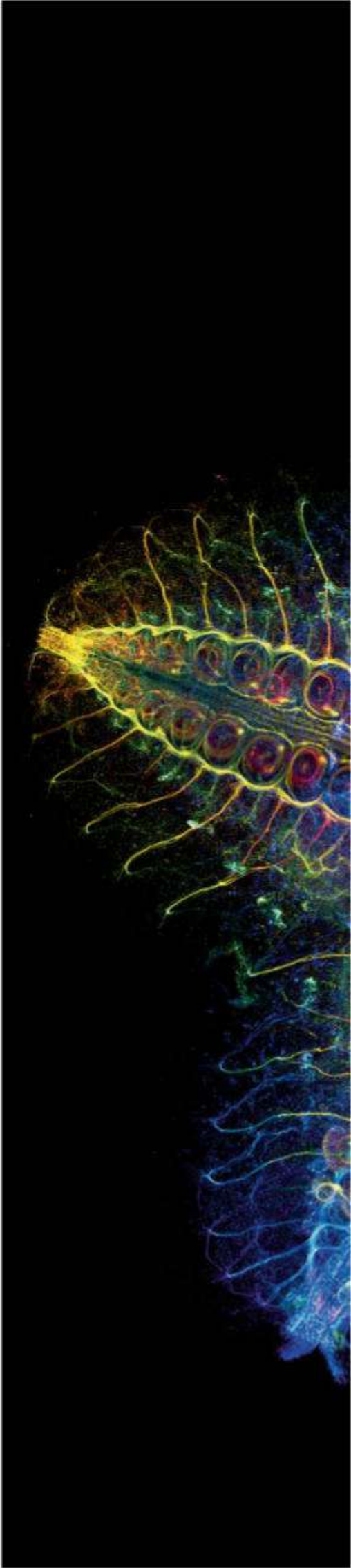
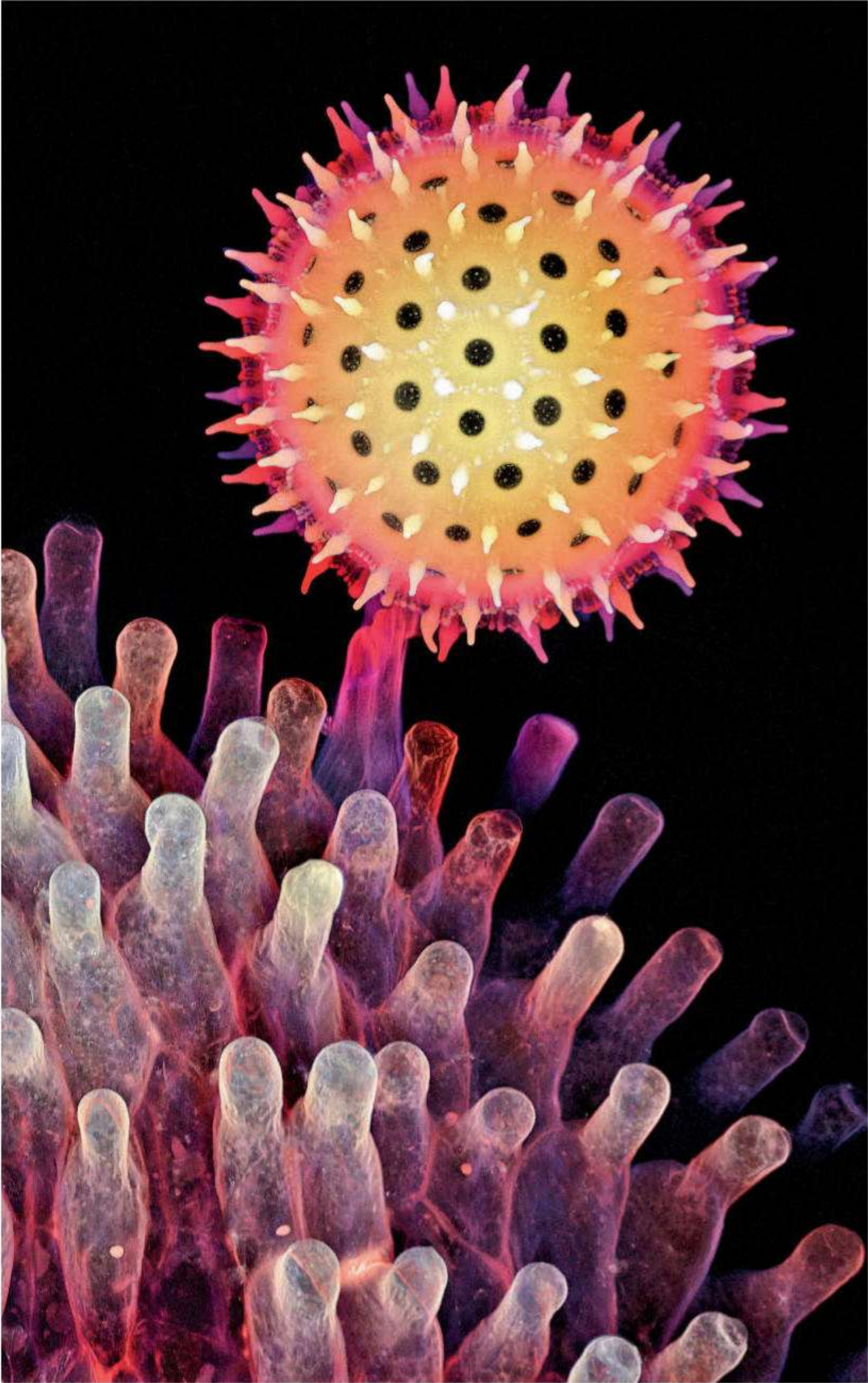
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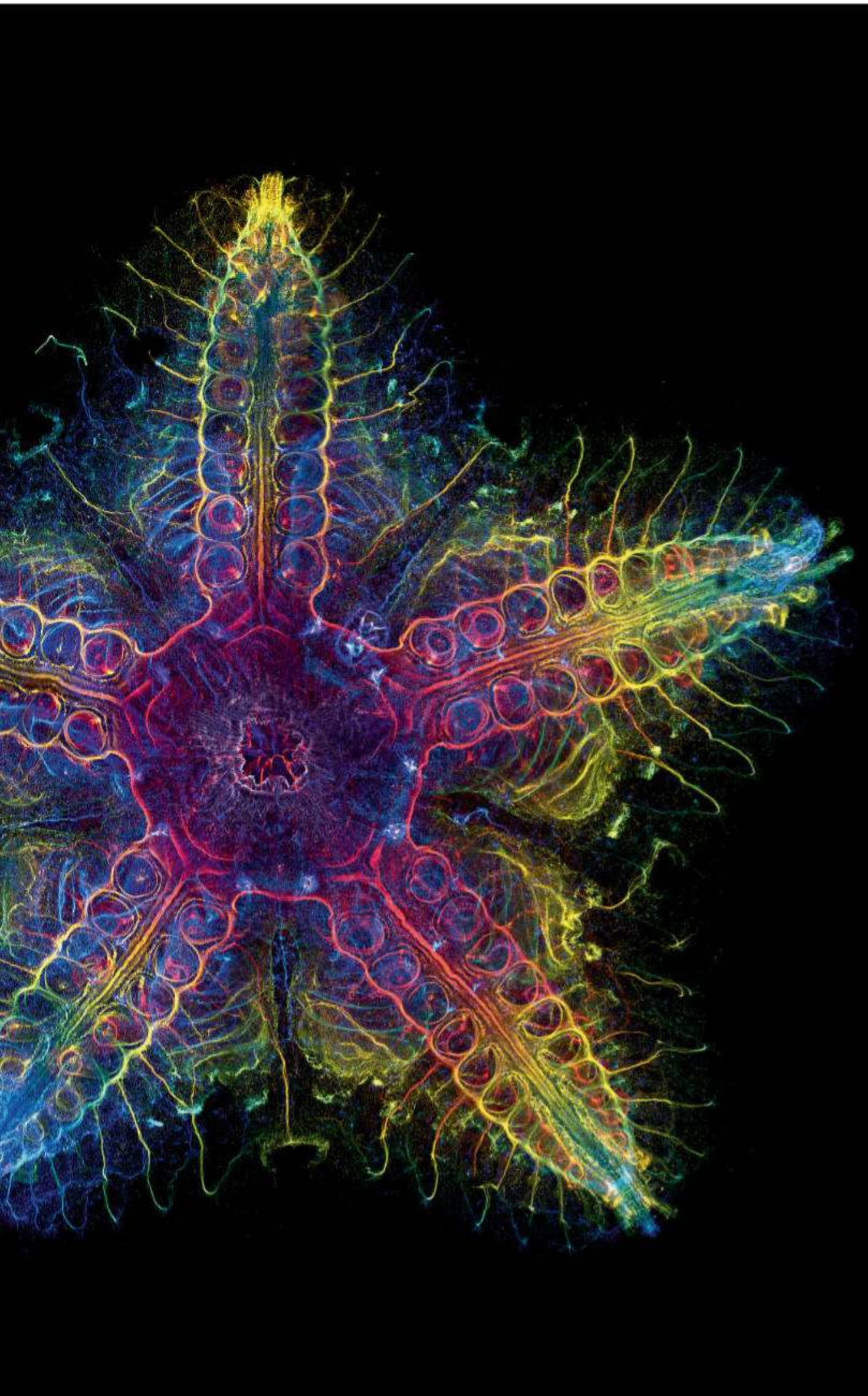
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Star power



Evident

THESE eye-popping pictures showcase the incredible views that can be captured through a microscope. They are two of the winners of the Global Image of the Year Scientific Light Microscopy Award 2022, run by microscope manufacturer Evident.

Laurent Formery at Stanford University in California scooped the top prize for his shot of the nervous system of a juvenile *Patiria miniata*, or “bat star” starfish (near left), that, with its network of fine fibrils, looks like it was plucked from another planet. Formery illuminated the animal’s nerves, which are spread throughout its entire body, by treating the 1-centimetre specimen with an antibody and then artificially colouring the resulting image.

His research focuses on marine invertebrates, particularly echinoderms such as starfish and sea urchins. “We know little about how these animals shape their fivefold body, which is the topic of my research,” he said in a statement. “I’m happy that taking images of them helps communicate how much beauty we have in our oceans, and why it is important to know more about them and protect them.”

Meanwhile, the winning entry for the Americas (far left) was taken by Igor Siwanowicz. It shows the germinating pollen grain of a morning glory flower attached to a stigma. The stigma, part of the plant’s reproductive system, fills the bottom part of the image and is covered in projections that help trap the pollen. ■

Gege Li

Editor's pick

AI's advances really aren't quite as great as we think

29 July, p 32

From Eric Kvaalen,

Les Essarts-le-Roi, France

The article on using artificial intelligence to tackle scientific challenges paints too rosy a picture of its accomplishments up to now. AlphaFold sometimes inaccurately predicts protein folding. The matrix multiplication methods found by AI only achieve a 10 to 20 per cent improvement for certain small matrices and only when using certain hardware. The sorting algorithms found by AI were 70 per cent faster only for a list of five items. The concrete formulation found by AI entails 40 per cent less carbon dioxide emissions only when compared with a form of "standard" concrete that hasn't been used much for the past 25 years.

From Sam Edge,

Ringwood, Hampshire, UK

I laughed when I read that AI could help create viable nuclear fusion power, with "energy so cheap that it could be given away for free".

Nuclear fission was supposed to be "too cheap to meter" as well. In fact, it has always been the most expensive energy fed into the grid.

The type of nuclear fusion being developed requires large, complex facilities, the mining, refining and transport of lithium and the not-so-easy extraction of deuterium from water for fuel. The neutrons emitted during fusion will also degrade the reactor, requiring us to replace parts or all of it on a regular basis, as well as find a way to safely dispose of the radioactive scrap.

Placenta may be scene of a battle of the sexes

22 July, p 40

From Rachel Mckeown,

Cambridge, UK

Jasmin Fox-Skelley's exploration of the long-term impact of

the placenta on health notes the genetic "conflict" between mother and fetus, but this doesn't factor in that the maternal and paternal chromosomes may express genes differently due to the phenomenon of epigenetic "imprinting".

Genes promoting placental growth may be highly expressed from the paternal chromosome, seeking to maximise offspring success. The same gene on the maternal chromosome may be inactivated to counterbalance its paternal partner, preserving some nutritional resources for the mother and future offspring.

Mutations in such genes can have different effects depending on whether they are inherited from the mother or the father, known as a parent-of-origin effect.

As such, the true "battle" may be one of the sexes, rather than the generations.

Solar panels can pave the way to green air con

22 July, p 10

From Guy Cox, Sydney, Australia

We may not need to turn our backs on the use of electricity to cool buildings. In the 19th century, most Australian houses were designed with passive cooling in mind and, having lived in a couple, I can attest that it was reasonably successful. But we are in the 21st century and have solar panels.

My son and his family live in a very ordinary suburban semi-detached home, and they have enough solar panels on their roof to run their air conditioning full tilt on the hottest day and still export electricity to the grid. We may get more sun than the UK, but we also get much hotter days.

Surely the UK government could mandate that a certain number of solar panels need to be installed

on a house before allowing it to have air conditioning?

Let's hear it for the clever seagulls too

22 July, p 20

From Georgina Skipper,

Wyke Regis, Dorset, UK

Reading that crows and magpies, well known as the intellectuals of the bird world, have been using the anti-nesting spikes on roofs as nest-building material, I have to let you know that, near Weymouth, UK, the gulls have been doing this for at least four years. Respect!

Personalised carbon tax is within our grasp

22 July, p 17

From Pete Drake,

Penmon, Anglesey, UK

There is no need to restrict a carbon tax to luxury goods. Access to utility and vehicle-use records, passports and international passenger information, as well as our financial records for an estimate of spending on goods, is within the grasp of authorities such that a reasonable reckoning of our mark on the planet is possible for each individual.

A personal carbon footprint tax would be feasible. It would hopefully help make each of us more aware and try harder to reduce our footprint, with the proceeds of the tax used to ensure a future for younger generations.

Is this why psychedelic treatments are back?

29 July, p 7

From John Reynolds,

Canonbie, Dumfriesshire, UK

While reading your article on the use of psilocybin to treat anorexia, and reflecting on the growing

number of reports on similar studies of the beneficial effects of controlled substances, I wondered if we are seeing a "generation drug" effect? Are those who lived through the normalisation of the use of recreational drugs in the 1990s and 2000s, perhaps shorn of earlier generations' reluctance, now in positions to initiate and direct such research?

Reasons to think crocks aren't totally redundant

22 July, p 44

From Ian Wilson,

Reading, Berkshire, UK

One reason to put crocks – scrap bits of pottery or polystyrene – into the base of a plant pot is that a relatively fine planting mix, for example for seedlings or cuttings, will fall through open drainage holes when dry or wash through when it is wet. The crocks can stop this. In addition, half-filling a large pot with polystyrene would make it far easier to move.

All hail the new drugs for treatment of obesity

15 July, p 32

From Jon Arch, Welwyn Garden City, Hertfordshire, UK

I spent much of my career trying to discover drugs to treat obesity. The class of drug that my team and I found to work well in rodents was ineffective in people. However, others found them useful in the treatment of overactive bladder.

How I wish that I had been involved in the discovery of semaglutide and the other treatments described by Clare Wilson in her excellent article.

I also totally agree with your related leader. Why the moralising about drugs for obesity, but not those for type 2 diabetes, which is usually associated with obesity? ■

For the record

■ Cosmic rays produce helium-3 and beryllium-10 in asteroids (22 July, p 16).



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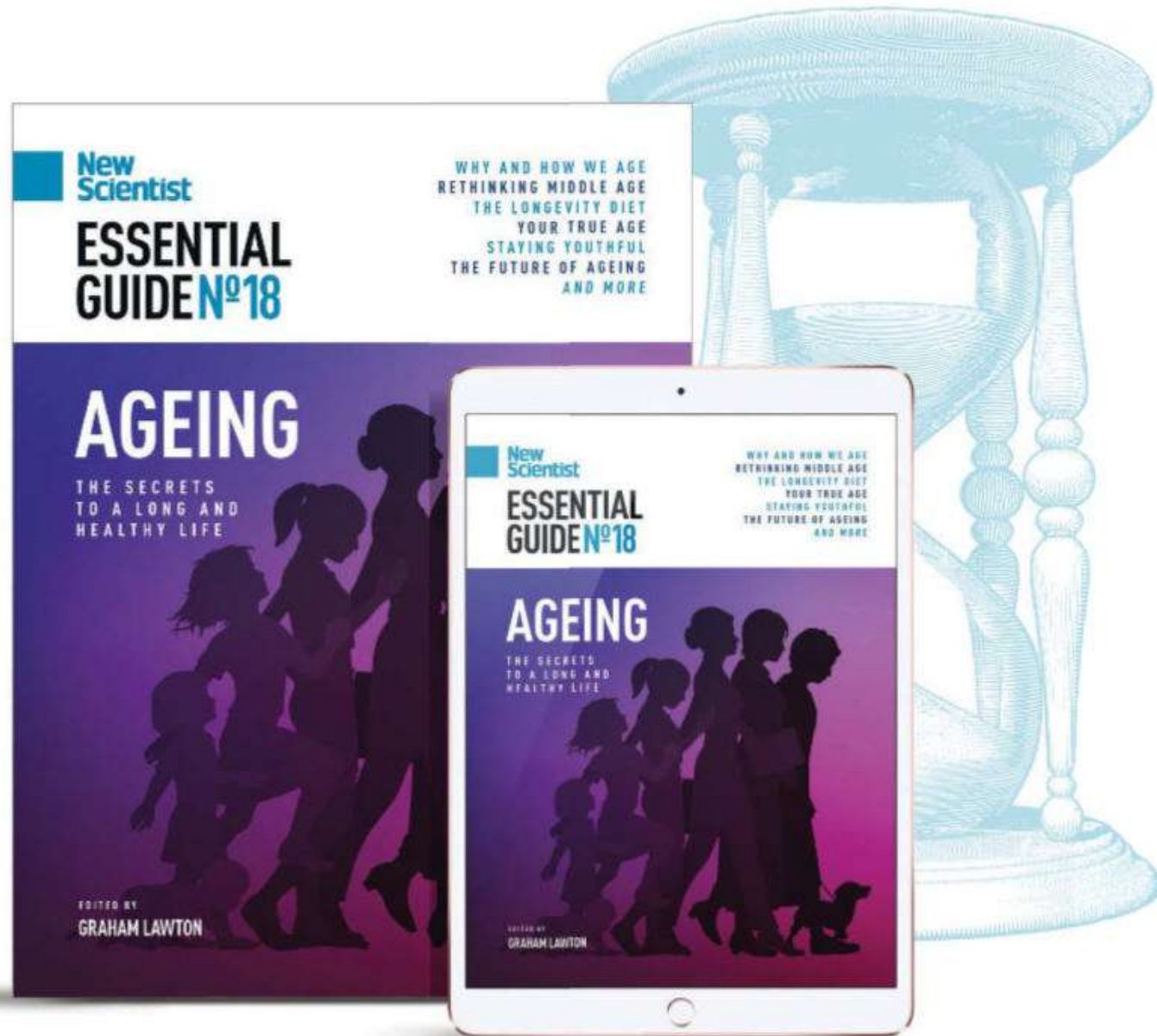
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A terrifyingly tight fit

Lee Berger was determined to enter the cave where fossils of the ancient hominin *Homo naledi* were discovered. But a dreadful journey lay ahead, finds **Alison George**



Book

Cave of Bones

Lee Berger and John Hawks
Penguin Random House

UNTIL now, the most horrific journey of scientific discovery I had read about was by Antarctic explorer Apsley Cherry-Garrard in his 1922 memoir *The Worst Journey in the World*. He describes, in dreadful detail, an expedition to collect Emperor penguin eggs in the dark Antarctic winter. Temperatures plummeted below -56°C (-70°F), his tent blew away and he barely made it back alive.

But to me, a journey undertaken last year by palaeoanthropologist Lee Berger is worse, as he ventured into the Rising Star cave system near Johannesburg, South Africa. Full of the same vivid detail as *The Worst Journey in the World*, we hear his story in *Cave of Bones: A true story of discovery, adventure, and human origins* by Berger himself and co-author John Hawks at the University of Wisconsin-Madison. Claustrophobes, look away now.

The story begins in 2013, when two cavers squeezed through an incredibly tight passage in the cave system to discover a bounty of fossil bones in what is now known as the Dinaledi chamber. These turned out to belong to a new hominin we call *Homo naledi*. This diminutive species may have lived relatively recently, up to around 250,000 years ago, and had a strange mix of primitive and modern features, with a brain size comparable to that of a chimp.

This discovery, alongside evidence that *H. naledi* seemed to have deliberately interred its dead, revolutionised our understanding of human evolution. Until last year, however, Berger was only



LUCASOLA/AFP VIA GETTY IMAGES

Lee Berger in the cave system where *Homo naledi* was discovered. Below: A reconstruction of a *H. naledi* child's skull

able to observe excavations in the Dinaledi chamber, where more than a thousand fossils of *H. naledi* have been found, via computer screen. The passage leading to this chamber, called the Chute, was so narrow that those who could enter had to be small and slight.

Berger decided to risk what the book calls the “dreaded 19cm squeeze” after losing 20 kilograms, even though, at 1.88 metres tall, it would still be tough. When he finally made it into the chamber, however, his efforts were immediately rewarded as he saw evidence of fire everywhere: soot

marks, charcoal and burnt bones. This, say the authors, shows *H. naledi* used fire to find a way into the cave system – a skill thought to be beyond a hominin with such a small brain. “The journey had been horrible, but I had... learned so much. The pain and fear were already worth it,” he writes.

Equally remarkably, on the walls Berger spotted engraved marks such as ladder shapes, triangles and crosses. Formal analysis has yet to take place, but Berger and Hawks are convinced they are by *H. naledi* – another skill thought to be limited to large-brained *Homo sapiens* and Neanderthals.

The Rising Star cave system is “like a *naledi* spaceship, access to an alien world in the midst of our own”, say the authors. Their book certainly conjures up the feeling of being in this inaccessible place.

Berger isn’t short on charisma, but he is also a controversial figure among archaeologists for his unconventional approach, such as his penchant for announcing major discoveries ahead of final academic analysis. “We have faced serious skepticism on this journey,” he writes. *Cave of Bones* doesn’t get into the details of

these controversies – perhaps rightly, as the book is firmly aimed at the general reader, not academics. Amusingly, Berger proves the point himself with

“Berger decided to risk the ‘dreaded 19cm squeeze’, after he lost 20 kilograms, though it would still be tough”

a cliffhanger at the end of the book, hinting that we may soon have some *H. naledi* DNA.

This would be a prize indeed. Meanwhile, after squeezing into the Dinaledi chamber, Berger had to face the even more terrible challenge of wriggling out, this time without the assistance of gravity. He describes “hanging, trapped in a situation where my body simply wouldn’t fit through the next tight space. This squeeze was the worst situation... I had ever been in my life.” Thinking he might die, he tried to dislocate his kneecap to lever his leg up.

Somehow, he made it – even he isn’t sure how. Frankly, I would prefer my chances in an Antarctic blizzard. ■



ULRICH BAUMGARTEN VIA GETTY IMAGES

Exploring the solo world

More and more people are staying single long term. A nuanced book looks into the effects of life lived alone, finds **Elle Hunt**



Book Alone

Daniel Schreiber
(Translated by Ben Fergusson)
Reaktion Books

"I never made a conscious decision to live alone," writes Daniel Schreiber. Yet for much of his adult life, the Berlin-based writer has done just that, not only as a sole resident, but as a single person. The challenges and contours of a life spent largely alone is the subject of Schreiber's reflective, elegantly written book – a bestseller in Germany and recently translated into English.

In eight essays, blending personal narrative and psychology, Schreiber explores contemporary solitude. Can friendship ever rival a romantic relationship for intimacy and support? Is it possible to reconcile independence and connection? How do single people best navigate a world that, despite widespread individualism, is still built for two?

These are timely questions: more

Lonely or independent? However you describe it, stigma is still directed at long-term singlehood

people than ever are staying single later in life. The same is true of single-occupancy households, as milestones like marriage, children and home ownership are pushed back or missed for many reasons, some economic and some social.

There is persistent stigma directed at long-term singlehood, but many in this group prefer to be "unattached": for them, it is an improvement on the convention of 2.4 children and a suburban house.

Others, like Schreiber, have mixed feelings, recognising the freedom, autonomy and opportunities for self-realisation in single living as well as the struggles and sacrifices. Chief among the latter, he suggests, may be reconciling the desire for a romantic partner without diminishing or endangering a life that otherwise feels satisfying.

The subject feels underexplored in ways that reflect nuanced reality. As Schreiber notes, research into relationships has focused on partnerships, and there is little on living alone. A recent wave of what he calls "life writing" on connection outside coupledness has tended to become a celebration of friendship.

But as vital as friendships are, for those without partners in particular, there are also limits. No matter how

much popular culture assures us that friends will be there for you, the reality is that even the closest platonic bond can struggle to register alongside family and work.

Alone opens as Schreiber, a former serial monogamist, grapples with his closest friend's decision to move out of Berlin to bring up her family, and his private, shameful suspicion that "something had gone wrong" for him still to be single.

This gets worse in the covid-19 pandemic, when the strict limits on socialising made it harder to ignore that he was no one's priority. (Which of us, in England, wasn't subjected to social anxiety by "the rule of six"?)

Schreiber writes perceptively of the pain of being "left behind" in love, and of the cumulative effect of routine loneliness and its insidious, stultifying impact on well-being and broader world view. His descriptions of mixed, murky feelings are evocative, moving and often instantly familiar.

Faced with such a gap in research, a less self-assured writer might have leant on tangentially relevant studies, but Schreiber applies psychology and sociology carefully, never rushing to flimsy conclusions or reaching for false connections.

Nor does he exempt himself from his inquiry. As much as he is concerned with society's treatment of single people and their place in it, Schreiber also interrogates the part he may have played in his solitude.

A personal journey through loneliness had the potential to be self-pitying, insubstantial, even suffocating, but Schreiber's restless, well-read self-reflection elevates *Alone*. With this thought-provoking, often profound book, he proffers a hand to anyone who may have felt irrevocably, irredeemably alone and says, "me, too". ■

Elle Hunt is a writer based in Norwich, UK



Chris Simms
Assistant news editor
London

On holiday, I swapped science for literature. First, I tried a resurrection: Denise Mina recreates Raymond Chandler's detective Philip Marlowe in her new book **The Second Murderer**. She



beautifully captures Chandler's staccato, witty style, although I found her Marlowe a fraction less admirable than the original. To compare versions, try Chandler's 1939 book, **The Big Sleep**, for lines like: "You're broke, eh? I been shaking two nickels together for a month, trying to get them to mate."

Then I enjoyed Chester Himes's 1957 book **A Rage in Harlem**, a searing work of crime fiction by a leading Black writer. It features a hearse full of gold and a conman dressed as a Sister of Mercy.

The Left Hand of Darkness (pictured) by Ursula K. Le Guin also impressed me. This 1969 sci-fi story, set on a planet where gender is fluid, examined binary concepts of gender and their influence decades before many were thinking about it.



ULRICHBAUMGARTEN VIA GETTY IMAGES

The film column

Getting a grip Christopher Nolan's *Oppenheimer* isn't just authoritative and intellectually triumphant, it addresses the paranoia around nuclear power and creates a perspective for us to understand the origin of our fears, says **Simon Ings**



Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings



UNIVERSAL PICTURES

J. Robert Oppenheimer (Cillian Murphy) watches a nuclear test in progress

of uranium. Yet the uranium-235 and plutonium in nuclear weapons usually come from civil reactors.

The post-war public might have warmed to nuclear power if not for powerful lobbying by oil firms. This is the factually accurate but too-loud-to-be-convincing stand Oliver Stone took in his documentary film *Nuclear Now*, released in 2022 and based on Joshua Goldstein and Staffan Qvist's book *A Bright Future*.

What do new nuclear power plants offer? They are small (able to fit in a shipping container or big truck), safe (in one type, vital parts dissolve long before criticality), powerful (with equivalent output to a large coal-fired power station) and clean (nuclear waste powers some designs). Yet Stone's film fails, largely by assuming viewers are buckets to be filled with facts.

We look askance at movies like 1979's *The China Syndrome* (by chance released soon before the Three Mile Island nuclear accident in Pennsylvania), which created an apocalyptic turn in the US mind. The 2016 film *Pandora*, however, which turned the triumph of the Fukushima disaster response into a nightmare, is worth noting for its cynicism. This South Korean thriller was all about internal politics, not nuclear technology.

Oppenheimer is a class apart. Nolan's story of an exceptionally conflicted and guilt-ridden man, played to eerie perfection by Cillian Murphy, gives us the perspective to understand the origins of our sense of the nuclear uncanny. It doesn't stoke our fears, but brings them to the surface to recognise and address. *Nuclear Now* marks a big moment in the technology, but it is *Oppenheimer* that will help us embrace it. ■



Films

Oppenheimer
Christopher Nolan
On general release

Nuclear Now
Oliver Stone
Video on demand

Simon also recommends...

Film

Threads

Barry Hines
Britbox

A fictional nuclear war reduces Sheffield, UK, to sub-medieval subsistence after 13 years of "winter".

Book

The Ministry for the Future

Kim Stanley Robinson
Hachette UK

A sprawling, gripping novel of our immediate future finds an uneasy but crucial role for nuclear power.

RADIATION isn't a pestilence, but read the medical studies following any accidental release of radioactive material and you could be forgiven for thinking otherwise. In the UK, for instance, around 12 kilograms of uranium oxide escaped via the towers of the Windscale power station from 1954 to 1957, giving about 300 people terminal cancer. The explosion at Chernobyl in 1986, which killed over 30 people immediately, is likely to have caused terminal cancer in 5000 people over the long term.

It is the vagueness in these figures that stokes fear. An invisible killer striking at random raises the hairs on the back of all our necks, however few its victims.

But by any objective measure, nuclear power is safe and getting safer. An earthquake on 11 March 2011 shook the planet and jolted Japan 2 metres sideways, yet no one died from acute radiation syndrome in the devastated Fukushima Daiichi nuclear plant, and studies found that the disaster didn't increase cancer rates. The oil industry kills 264 times as

many people as the nuclear industry to produce just over seven times the useful energy.

It is all very well fulminating about "irrational" responses to nuclear power, but it is a different matter to get to grips with them. Christopher Nolan's magisterial biopic *Oppenheimer* isn't so much about J. Robert Oppenheimer's

"No one died from acute radiation syndrome in the devastated Fukushima Daiichi nuclear plant"

development of the atomic bomb (the Trinity test, the first nuclear detonation, is in the middle of the film not its climax) as it is about the paranoid turn history took in the wake of his triumph.

Read Serhii Plokhyy's book *Atoms and Ashes* for how "atoms for peace" encouraged nuclear proliferation. The phrase, from a 1953 speech by US President Dwight Eisenhower, aimed to balance fears of nuclear armament with promises of the peaceful uses

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THERE is a (probably apocryphal) story about Henry Ford sending agents out to junkyards across the US in search of scrapped Model Ts. The famous industrialist wanted to know which of the car's vital components failed first, so he could do something about it. The agents reported back that every bit of the car was susceptible to failure, but some were more susceptible than others, except for one – a component of the steering system called the kingpin, which almost never failed. They expected Ford to announce plans to extend the working lives of the weaker components. Instead, he ordered his engineers to make less resilient kingpins. No point wasting good money on a component that always outlived the others.

As in Model T Fords, so, too, the human body. All of our parts are susceptible to the ravages of time, but it turns out that some age more quickly than others. Exactly which parts fail first is a bit of a lottery. "Everybody's ageing differently," says Michael Snyder, a geneticist at Stanford University in California. You might have a young immune system but elderly kidneys, for example, or a decrepit metabolism but youthful liver.

Now, studies have revealed that we tend to age down one of four different pathways. This is your "ageotype" – the principle way in which you, personally, are ageing. The bad news is that the oldest part of your body may be dragging the rest of it down. The good news is that by working out your ageotype, you might

be able to target it to live healthier for longer.

The discovery of ageotypes has its roots in the "omics" revolution that started in the 1980s. First came genomics, the study of the genome – an organism's entire complement of DNA. Then came proteomics, the study of proteins; lipidomics, which focuses on fats; microbiomics, which deals with the bacteria, viruses and fungi that reside in and on our body; and more. When these are applied in combination and alongside standard medical diagnostics to investigate an individual's health status, it is known as "deep phenotyping", a discipline whose maxim is "the deeper you go, the more you know".

Going deep

Deep phenotyping has been used to probe the causes of all kinds of conditions, including cancer, heart disease, allergies, Parkinson's disease and addiction, to name just a handful. Until recently, however, it hadn't been applied to what is arguably the world's most serious and deadly condition: ageing.

Snyder and his colleagues decided to fill that gap. They selected 43 people aged 29 to 75 who were already enrolled in a different study. The volunteers had been deep-phenotyped at quarterly intervals over the previous two to four years. The researchers recorded data on their gene expression, metabolites, proteins, immune systems and stool and nasal microbes, while also performing a set of

standard blood tests. All told, Snyder's team had access to 18,393 data points for each volunteer per quarterly test, then analysed them to see which changed significantly over the study.

This longitudinal approach – looking at the same individuals over time – is in contrast to most studies of the biology of ageing, which usually examine a group of older people and a group of younger people and note the differences between them. These studies risk comparing apples with oranges, as the older cohort may have lived in environments or had lifestyles that are no longer common in today's world, including things like indoor smoking, different diets or more physical jobs. "Some of the stuff could be era effects as opposed to ageing effects," says Snyder.

The new approach allowed Snyder and his colleagues to identify 608 molecules, genes and microbial species that changed significantly as the volunteers aged, even within the short window of a few years. Many were already known biomarkers of ageing, but many weren't.

Then came the revelation. Most of the microbes, genes and molecules turned out to be associated with ageing in one of four distinct organs or systems – the kidneys, liver, immune system and general metabolism. But not everybody showed the same pattern of change. Most aged along all four trajectories at once, but with one or two predominating. "We kind of expected it," says Snyder, "but it's nice to see that you can measure it, and if you can ➤

Everyone has a specific part of their body that ages faster than the rest. Work out what it is and you could live a longer, healthier life, finds **Graham Lawton**

The four ways to age





CRYSTAL SPIRES/LAMY

measure it, you can do something about it.”

Snyder dubbed these four broad categories ageotypes. In an immune ageotype, the immune system is biologically older than the other three. Ditto the others. It is just like the model Ts: the whole thing gets older over time, but some parts wear out quicker.

The implication is that different people will benefit from different anti-ageing strategies. “You can intervene and reverse some of these trends. We think the information is actionable through lifestyle changes,” says Snyder. He recommends metabolic agers could try to lose weight and exercise more – many studies show that a healthy weight and regular exercise can improve the processes by which the body converts food and drink into energy. Likewise, liver agers may want to quit the booze, which is related to an increased risk of liver disease. Kidney agers should drink more water – studies suggest that higher water intake is associated with a lower prevalence of chronic kidney disease and slower kidney function decline. Immune ageing is characterised by a propensity towards chronic inflammation, which underlies many conditions of ageing, so Snyder suggests that immune agers

“A one-year increase in cardiovascular age drives a roughly 27-day increase in overall brain age”

Lifestyle changes like quitting alcohol may slow the ageing of the liver

could take turmeric or its active ingredient curcumin, which some clinical trials have shown have anti-inflammatory properties.

Happily, there are hints that some of these strategies might work. Four people in Snyder’s study reversed some of their biomarkers of metabolic ageing, two by losing weight, one by taking up exercise and another by changing diet. Eight kidney agers also showed improvement, though Snyder isn’t sure how. They were all prescribed statins to help lower cholesterol during the study, but the link to kidney function is unclear, he says. “I don’t think they’re truly reversing their ageing per se, but they’re getting some [aspects] of their ageotype under control.”

So how do you discover your own ageotype? Unfortunately, there is no bespoke test as yet, but Snyder says there are a few red flags to be found in standard clinical blood work. Liver and kidney function are routinely monitored, as is the level of C-reactive protein, which is an indicator of inflammation and hence immune function. Metabolic health can be roughly gauged via levels of a protein called haemoglobin A1C, which is associated with the processing of blood glucose and was routinely high in the metabolic agers in Snyder’s study.

The four ageotypes are just a start. There are certainly more, says Snyder. His study was small and drawn from a limited geographical area, so is unlikely to have captured all ageotypes, says Brian Piening at the Providence Cancer Institute in Oregon, who wrote a commentary on Snyder’s research.

There are already hints at what others might exist. One of the volunteers in Snyder’s study appeared to have a cardiac ageotype, with a heart that was biologically older than the rest of their organs. But more examples are needed before this ageotype can be confirmed. The same applies for some other ageotypes, says Snyder. His team is now deep phenotyping a larger group of volunteers to establish more ageotypes. The researchers have almost finished collating quarterly data over many years from more than 100 volunteers and will start analysing that data later this year.

In the meantime, other researchers claim to have extended the range of ageotypes already.

Earlier this year, Kalliopi Gkouskou at the University of Athens in Greece and her colleagues reanalysed Snyder's data using different methods and unearthed five more potential ageotypes: those involving the reproductive system, sensory systems, gastrointestinal system, central nervous system and connective tissue.

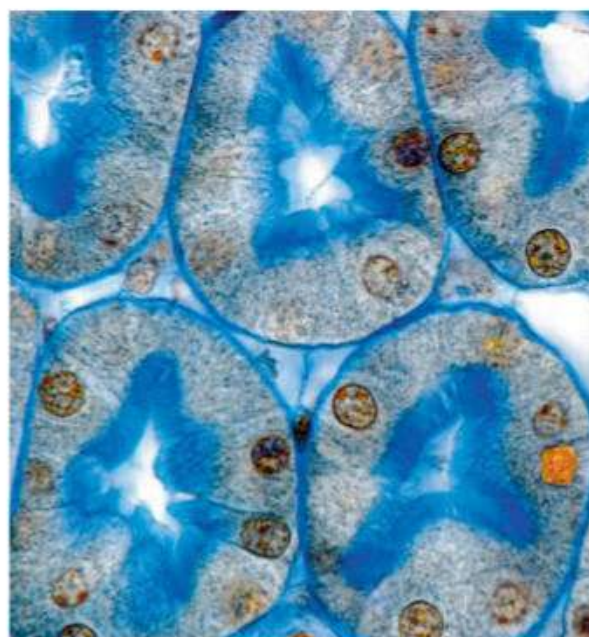
Likewise, in another study earlier this year, Brian Kennedy at the National University of Singapore and his colleagues applied deep phenotyping to 4066 volunteers aged between 20 and 45. They gathered information about their gut microbiome, immune system, metabolism, blood chemicals, body composition, physical fitness and facial skin, creating 403 data points for each individual.

The measurements clustered into nine ageotypes: the same four that Snyder's original study found, plus cardiovascular, physical fitness, sex hormones, facial skin features and gut microbiome. Of these, the gut microbiome was least likely to correlate with chronological age in any individual, while the liver age and sex hormone systems varied the most between individuals. This suggests that ageotypes are a real phenomenon, says Kennedy.

Old organs

Meanwhile, Ye Ella Tian at the University of Melbourne, Australia, and her colleagues have dug into the impact of ageotypes on health. Earlier this year, they used data from the UK Biobank, which contains genetic, medical and lifestyle information on 50,000 middle-aged people in the UK, to develop ways to measure the biological age of seven body systems (cardiovascular, lungs, musculoskeletal, immune, kidneys, liver and metabolism) and three brain systems (grey matter, white matter and brain connectivity).

They confirmed that different organs and systems can age at different rates within an individual and, unsurprisingly, that the oldest parts of a person's body were strongly correlated with age-related conditions they had been diagnosed with. People with renal disease had kidneys that are eight to 11 years older than their chronological age; those with



JOSE CALVO/SCIENCEPHOTO LIBRARY

Drinking more water can slow the ageing of kidney cells (pictured)

diabetes had older metabolisms and people with aged cardiovascular systems were more likely to have chronic obstructive pulmonary disease (COPD). Advanced brain age was often seen in people with mild cognitive impairment, dementia and Parkinson's disease. More surprisingly, though, they found that many age-related conditions were linked to organs not typically associated with them. Advanced brain age was often seen in people with COPD and diabetes, for example.

Tian's team also discovered that organs and systems don't age in isolation; they can drag others down with them. For example, a one-year increase in cardiovascular age drives a roughly 27-day increase in overall brain age. Rapidly ageing lungs lead to faster cardiovascular ageing, which in turn causes more rapid ageing of the muscles, bones and kidneys. This is perhaps due to the malign influence of senescent cells – aged, irreversibly damaged cells that don't die, but instead hang around causing bother, dripping toxins into the bloodstream and poisoning distant tissues.

But the causes of differential rates of ageing in the same body aren't yet fully understood. "There might be some genetic factors," says

Tian. "Sometimes, some organ system might have a genetic predisposition that makes it more vulnerable than others. But also there are probably lifestyle factors like smoking, exercise and socioeconomic status." Snyder similarly says it may be down to a combination of genes, environment, lifestyle and medical history.

When the data is all crunched, there are likely to be dozens of ageotypes, says Snyder. "There's 78 organs [in the human body] – are there going to be 78 ageotypes? I don't think it's unreasonable to say 50 major ones." But the fact that some of these organs age in tightly coupled ways means that this list could be whittled down to 20 or so, he says.

All in all, the discovery of ageotypes promises to further personalise anti-ageing medicine, allowing doctors to intervene in organs and systems that are ageing fastest. And it is possible now. "Most of the clinical markers we used are available in clinical settings, so in principle those markers can be used to estimate the organ age," says Tian. "And at that stage, I think the clinician can advise some early behaviour interventions to try to delay onset of disease."

There is, however, a downside. Ageotypes cast doubt on the validity of biological age tests, says Kennedy. These generally take DNA from a very limited sample, either saliva or blood, and miss the bigger picture. "Many aspects of the human body would not be covered," he says, possibly lulling people into a false sense of security – or the opposite.

I am pretty sure I am a liver ager. I had a nasty bout of viral hepatitis when I was a teenager and haven't really looked after my liver since, regularly bombarding it with toxins, mostly ethanol. I suspect it is the most decrepit part of my 53-year-old body. But there is something I can do: eat less fat, lose a bit of weight and take an extended trip on the wagon. My liver will never be a kingpin, but I can stop it dragging the rest of me to the junkyard. ■



Graham Lawton is features writer at *New Scientist*

Rivers of filth

Enormous volumes of sewage-contaminated water are dumped into Britain's waterways, but there are clever ways to stop the deluge, discovers **Michael Marshall**

TENS of metres under central London a tunnel has been dug that stretches 25 kilometres at a cost of £4.3 billion. Boring was completed in April 2022 and the passage should start operation in 2025. The 7.2-metre-wide Thames Tideway won't carry people or vehicles though, but sewage.

This "super sewer" will collect the huge volumes of stormwater and waste that often overwhelm London's ageing sewage system. Instead of being dumped into the Thames estuary, as happens now, the effluent will gush through the new tunnel to Europe's largest sewage treatment works at Beckton, on the outskirts of the city.

The Thames Tideway is the most conspicuous example of the UK's attempts to stop dumping sewage into rivers, amid growing outrage towards the privatised water companies responsible for the waste system. But this new infrastructure is just the tip of the iceberg when it comes to solving this crisis, which is linked to wider issues of how water is managed and even climate change. The good news is that technical solutions already exist, many of which are win-wins: helping to solve sewage overflows as well as problems such as flooding and drought.

While many forms of pollution foul Britain's rivers, sewage has grabbed the limelight. News programmes have repeatedly shown footage of dirty slurry tumbling into pristine river waters. The main culprits are combined sewer overflows (CSOs), designed for when water from heavy rain is carried into the sewage system and must be discharged due to its high volume – taking waste with it.

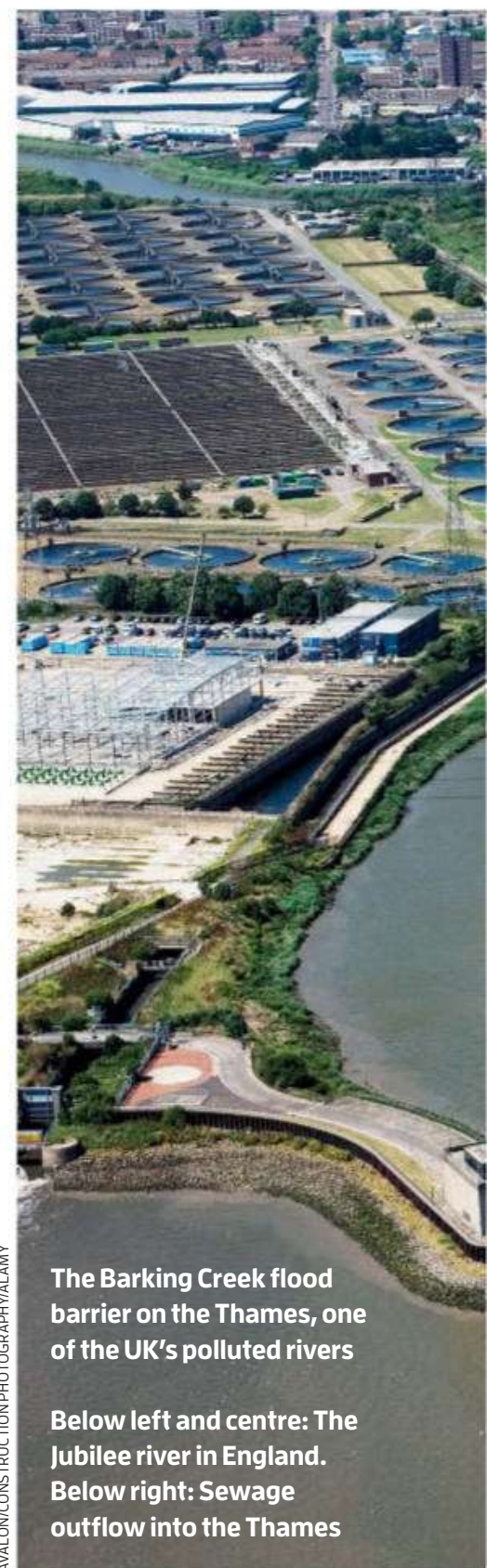
Campaign and conservation groups such as Surfers Against Sewage, The Rivers Trust and Top of the Poops have compiled data on CSOs in Britain. Their headline numbers don't make pretty reading. Top of the Poops

reports "at least 361,103 'sewage spills' into English rivers in 2022, lasting an almost unbelievable 2,207,527 hours".

It is tempting to assume that rates of sewage dumping must have increased, but we have only had systematic data collection from CSOs for a few years. Water companies were encouraged to install monitors by a 2013 letter sent by Richard Benyon, the then UK minister for natural environment and fisheries. Benyon wanted "the vast majority" of CSOs to be monitored by 2020. As a result, coverage in England increased 14-fold between 2016 and 2020. In March this year, the UK government reported that more than 91 per cent of storm overflows in England now have monitors. This expansion of monitoring has revealed the current scale of sewage dumping.

The issue has become strongly politicised. A common narrative is that privatised water companies have siphoned off profits while failing to invest enough in infrastructure. In England, the companies have paid shareholder dividends averaging £2.1 billion a year and have £54 billion of debt. Yet Scottish Water remains publicly owned and it allowed sewage to overflow 54,289 times between 2017 and 2021. It also lags behind English companies in installing CSO monitors.

Instead, the problem of sewage dumping can be traced to Britain's antiquated water management infrastructure. Many of its sewers date to the 19th century and carry both sewage and excess rainwater. "Our stormwater and wastewater are collected by a single drainage system," says Luiza Campos at University College London. The aim was to reduce the risk of flooding. "When it rains hard, rather than your property being flooded, it'll go into a sewer and be taken away," says Tom Stephenson at Cranfield University in the UK. The sewers transport the mix of municipal



The Barking Creek flood barrier on the Thames, one of the UK's polluted rivers

Below left and centre: The Jubilee river in England. Below right: Sewage outflow into the Thames





sewage and rainwater to wastewater plants (see “How sewage treatment works”, page 38). The downside of this combined system is that heavy rainfall can overwhelm the wastewater treatment plants. If too much water flows into the system, the sewers back up, risking raw waste welling up into people’s homes.

Two major things have been done to reduce this threat. First, engineers estimate how big a flow a treatment plant might experience and design it to cope. “You have to build the sewage works bigger than you might do for the average flow,” says Stephenson. Second, plants are fitted with an overflow system. When too much water enters, some is diverted into overflow pipes and out into rivers and other waterways. Inevitably, some sewage goes too. “They [CSOs] are deliberately discharged so you haven’t got sewage bubbling up into your toilet,” he says. “You’re protecting properties, people and businesses from being flooded.”

In other words, CSOs are an inherent part of a combined sewer, but they are supposed to be a rarely-used backstop. Furthermore, if they are operating properly, they are relatively safe. That is because overflows should only happen at times of really heavy rain, when rivers are running high. This waters down the discharged sewage to the levels seen after treatment.

Yet the system clearly isn’t working properly. In the past few years, several water companies have been prosecuted for polluting rivers and other water bodies in the absence of rain.

As well as this, the idea of CSOs as a last-resort system is difficult to reconcile with the hundreds of thousands of dumping events every year. In the Netherlands, they only happen “once or twice a year”, says Mark van Loosdrecht at Delft University of Technology in the Netherlands. “If it’s more often, yes that’s a problem.”

While sewage isn’t the biggest source of pollution in Britain’s rivers (the leading cause is the runoff of slurry and sludge from farms), it is a threat to our health and the environment. Combined sewage and stormwater can include “high levels of bacteria, pathogens, pharmaceuticals and personal care products, heavy metals, sediments, microplastics and tyre wear particles”, says Campos. “Pathogens present in the untreated sewage can cause illnesses such as gastroenteritis, hepatitis and other waterborne diseases.”

The upshot is that Britain’s rivers aren’t reliably safe to swim in. Of 1500 rivers, only stretches of three are designated bathing





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sites – and even these aren't judged to be safe for swimmers. There has also been a change in attitudes. "I think people, quite rightly, are less tolerant of having a filthy stream running through the middle of their town than they used to be," says Stephenson.

England's water companies are at least alive to the problem. In May, they apologised for the pollution and pledged to spend £10 billion this decade to clean up their act. Industry body Water UK says this amounts to a tripling of existing investment plans and should cut spills in England by up to 140,000 per year by 2030 compared with the 400,000 in 2020. The money is likely to come from water bills, which might need to rise by more than £50 per year to cover the costs.

The big clean-up

So far, the companies haven't given any details of their plans. What will it take to stop sewage flowing into Britain's rivers?

Britain's wastewater treatment plants are perfectly capable of handling the volumes of sewage they receive and the technology is constantly improving. "I've been at this for roughly five decades and the pace of change is faster than it's ever been," says Glen Daigger at the University of Michigan.

Instead, the problem is that the sewers can't cope with the amount of water they receive at certain times and this indirectly causes the sewage to escape. "You have to deal with this volume," says van Loosdrecht.

The obvious solution is to stop using combined sewers, but that is far from trivial. New housing estates are already built with separate sewers and rainwater drainage. However, that still leaves much of the country with the old, combined set-up. Replacing it would be a huge, expensive project. "You've got hundreds of billions of pounds of infrastructure built like that," says Stephenson.

It also isn't a perfect solution. "Even the rainwater itself flushes all kinds of dirt from the streets", including animal faeces, says van Loosdrecht. Large volumes of this contaminated water can still cause harm if regularly discharged into a river, so the rainwater may still need to be sent to a treatment plant – recreating the problem.

A better approach is to take a step back and consider the full range of problems facing Britain's water. "What are the things that we can do that address the system as a whole?"

says Daigger. This holistic method, advocated by the United Nations, is called Integrated Water Resources Management and is based on the premise that water is a vital resource for both people and ecosystems.

In the UK, this points to a simple truth. "We have two problems: too much water or too [little] water," says Campos. While Britain is famously rainy, the water isn't evenly spread in time or space. South-east England is particularly prone to droughts. Other regions, like the south-west, can receive intense rainfall from the Atlantic, leading to floods.

Global warming will worsen both problems. "Climate change is increasing the frequency and severity of storms," says Daigger. It will also make droughts more frequent and intense. As the weather becomes more changeable and extreme, more sewage will



Many of the UK's sewers were built in the 19th century and are unfit for modern Britain

How sewage treatment works

The aim of a sewage treatment plant is to clean water sufficiently for it to be safely discharged into a body of water like a river. This treated water doesn't have to be as crisp and pure as a mountain spring, but it must be clean enough that it doesn't harm the ecosystem or pose a significant risk to people's health.

A wastewater treatment plant works in stages. First, filters remove "the gross solids, in both senses of the word: the nasty stuff, but also the big stuff", says Tom Stephenson at Cranfield University in the UK. This includes items such as condoms and supposedly flushable wet wipes, which shouldn't be flushed down toilets, but often are. A second step filters out small, but dense, particles like grit and sand.

The core challenge is the stuff that comes directly from the body, which forms the bulk of the pollution. "The big problem is the poo and the wee," says Stephenson. "You've got to remove the organic matter, you've got to remove the ammonia."

As a first step towards this, the sewage is stored in tanks. Here, gravity

drags the denser organic particles to the bottom, where they form a sludge. This is treated separately: sometimes it is used to produce methane, which can be burned to generate energy, or it may become a soil improver.

Meanwhile, the bulk of the water is still contaminated with organic chemicals like fats and proteins, and with ammonia. Here, the trick is to harness microbes that break down the waste and get them to work quickly and efficiently. "You blow air or you provide oxygen and bacteria grow," says Stephenson. "They degrade the organic matter and, if you get the conditions right, you can also convert ammonia to nitrate, which is far less toxic."

Most people have never set foot in a wastewater treatment plant and so have a lot of misconceptions, says Stephenson. People imagine "a horrible brown water with lots of turds floating in it", he says. "It isn't. It's a slightly muddy river." And while the microbial processes do smell, the whiff resembles "strong earth" rather than a broken toilet.



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be forced out of combined sewers by extreme rains. “These overflows, which are a designed component of the system, are occurring more frequently and with higher volume.”

In this context, says Campos, we need to collect more rainwater where it falls. “Avoid the stormwater being discharged into the drains,” she says. That way, we can delay it entering the sewers, reducing the risk of overflows. The water can either be used immediately or stored to help with subsequent droughts.

There are many ways to do this. We can collect the stormwater in tanks or artificial lakes that become amenities for communities. On a smaller scale, many more homes could have water butts attached to their drainpipes, with the water used for gardening.

“San Francisco is one of the best examples of how a significant metropolitan area is addressing this,” says Daigger. New rules enable developers to install rainwater collectors and for the captured water to be put to use – often for non-drinking purposes like flushing toilets. “This gets down into things like plumbing codes and the building trades and so forth,” says Daigger. “Here’s quite a significant international city that’s moving very systematically in a water-short area.”

Alternatively, we can harness nature. Buildings with green roofs naturally absorb some rainwater. Many new housing estates in the UK now have a swale: a wide, shallow ditch that captures rainwater. A swale enables this water to slowly drain away, rather than flowing

“Cities can install ‘rain gardens’ that collect runoff and control the flow of water”

The Thames Tideway is a “super sewer” running under central London



PATRICIA RAYNER/IMAGE 2 PHOTOGRAPHY

quickly over paved surfaces straight into the nearest sewer or river.

Swales are just one example of a sustainable drainage system. “We can also implement ‘rain gardens’ in urban areas,” says Campos. These are planted areas of ground that collect runoff. For example, in many British towns and cities, roundabouts that were once made solely of concrete have been turned into miniature gardens. There are plenty of other hard, paved areas that can be planted and this would lead to leafier cities as well as helping to control the flow of water.

Where space is available, artificial wetlands can also control water flow. The best designs have a layer of gravel or sand, which filters muck out of the water as it drains through, says Campos. The water can then trickle out into a river. Projects like these are being attempted in the UK. In May, South West Water announced it would pay farmers in Devon and Cornwall to store water on their land, variously using ponds, woodlands and wetlands. The company has been given £1 million of funding for the scheme by Ofwat, the UK regulator for water and sewerage firms.

Campos emphasises that there is no one-size-fits-all solution. Wetlands probably aren’t viable in a densely-populated city like London, which is why the Thames Tideway tunnel has been built. But in smaller towns and rural areas, such huge infrastructure projects would be unsuitable. The challenge will be running Britain’s water system in a joined-up way. “The technical solutions are there,” says van Loosdrecht. “The main issue is in the governance and the political decisions.”

It remains to be seen whether the UK government will enact the kind of joined-up thinking needed to tackle not only the sewage problem, but wider issues of water resources. Last month, a handful of Londoners went on a subterranean journey to see the kind of interventions needed, venturing into the Thames Tideway before it comes into use. For the occasion, a stretch of the tunnel had been turned into a garden-like art installation. However, wastewater will shortly take its place – and the sooner we face up to the reality of the disposal of our sewage, the better. ■



Michael Marshall is a freelance writer based in Devon, UK

WHEN scientists reported they had created a space-time wormhole in November last year, the world's media were all over the story, even though they struggled to make sense of it. A journalist for the website UNILAD put it neatly when they wrote: "So, you might have to bear with us here a bit, because it's all very complicated and new."

As far as many observers could see, physicist Maria Spiropulu at the California Institute of Technology and her colleagues had in fact merely used a quantum computer to simulate a wormhole. Good luck flying a spaceship through that. What confused matters was that the team insisted the work amounted to more than just a simulation. The quantum computation, the researchers said, was fully equivalent to the creation of a wormhole.

If you find that hard to swallow, you aren't alone. Ask other physicists about Spiropulu's claims and you tend to get a lot of long pauses, chin-stroking and disagreement. It seems there is genuine confusion about if and when a quantum computation can create real entities or just simulate them.

The putative wormhole isn't the only thing said to have been conjured up by quantum computers recently – there is also the alluringly named time crystal, as well as strange particles called nonabelions, touted as the ideal ingredient for next-generation quantum computers. But whether these amount to instances of true creation or not is a question that takes us into deep waters. It is a new twist on the riddle that has haunted physics since quantum mechanics was devised in the early 20th century: what is truly real?

Regular computers use transistors as switches to encode the bits, or 0s and 1s, of binary code. We can use them to simulate all kinds of objects and processes – but it would be absurd to suggest that a simulation of a molecule or a weather system, say, really creates those things. So why should quantum computers be any different?

In place of encoded 1s and 0s, quantum computers instead use quantum bits (or qubits). These are typically quantum particles, like photons or cold atoms, whose properties are described in the language of quantum

When does a simulation become real?

Physicists recently claimed to have created a wormhole using a quantum computer. The surprising debate that followed takes us to the heart of what quantum physics means, finds **Philip Ball**





ULA ŠVEIKAUSKAITĖ

mechanics, using an abstract mathematical object called a wave function. Quantum rules permit qubits to be entangled with one another, so that what happens to one apparently influences what happens to others. That is generally how this type of computation can speed up certain kinds of calculation. In other words, the qubits inside a quantum computer are described by the same theory that explains the fundamental particles that make up everything. This is what motivated the proposal for such computing first made by Richard Feynman in 1981. Why not, he said, simulate physical systems using the same quantum rules that govern those systems themselves, instead of clumsy approximations with conventional bits?

To see why this blurs the boundaries between simulation and reality, let's put wormholes aside for a moment and look at another recent experiment using quantum computers. It concerns a particle called a non-Abelian anyon (or nonabelion for short). These are a variety of anyon, a kind of particle first hypothesised by theoretical physicist Frank Wilczek in 1982. Anyons have odd properties in between those of the two normal classes of fundamental particle: bosons, which carry forces, and fermions, which constitute matter.

In 1997, physicist Alexei Kitaev showed that hypothetical nonabelions can be moved around each other (or "braided", as physicists put it) to preserve a memory of those movements in a way that could encode quantum information robustly. This means nonabelions could act as qubits that aren't prone to the kind of random errors that bedevil existing quantum computing. Kitaev argued that such nonabelions could be created as "quasiparticles" in certain materials – that is, as collective emergent states of the electrons in these materials.

Despite several claims to the contrary, there is no compelling evidence that such nonabelion quasiparticles have been created in real materials. But in June, teams of researchers at Google Quantum AI in Mountain View, California, Zhejiang University in Hangzhou, China, and quantum computing company Quantinuum's labs in Germany and Colorado claimed to have made these entities in quantum computers. They coaxed the qubits into states that have wave functions corresponding to the strange predicted properties of nonabelions. But was this an act of creation – or just simulation? ➤

Imagine, say, that we want to model a hydrogen molecule on a quantum computer. The molecule is made of two protons bound by a cloud of electrons. A quantum simulation may have exactly the same wave function as these components, but it clearly isn't the same as the real-world object. We know what a hydrogen molecule is, and it's not a collection of qubits.

This is the framing used by Adam Zalcman at Google Quantum AI to explain why he thinks the team really “made” nonabelions in a quantum computer chip. When you ask if a simulation is “real”, he says, the question is whether what the quantum computer is doing has a real-world equivalent to be “mapped onto”. If so, then you have a simulation. But if you are studying a more abstract phenomenon, say, quantum entanglement, then generating it using qubits doesn't lack anything present in that phenomenon itself. “Entangling two qubits in a quantum processor does not involve mapping their states to that of any system distinct from the processor itself,” he says.

Nonabelions, meanwhile, are hypothetical particles that – as far as we know – don't exist in reality at large. So, for Zalcman, there is nothing to be mapped onto. The only way we can define a nonabelion is based on its quantum properties. “The process that occurred on the chip is non-Abelian braiding and we therefore say that our investigation is a realisation, not a simulation,” says Zalcman.

Computer scientist Scott Aaronson at the University of Texas at Austin also alights on this issue of mapping. “It depends on what sort of ‘thing’ we're talking about,” he says.

A computer simulation of a hurricane “doesn't make anyone wet, but a computer simulation of multiplication is multiplication”, he says.

Wilczek also conceived of an entirely different kind of quantum object that now features in this debate. In 2012, he was looking for a way to spice up a university course he was teaching on the structure of crystals, whose atomic arrangement repeats periodically in space. He speculated about a crystal that repeats not in a spatial dimension, but in time. The components of these time crystals would change with the proverbial ticking of the clock (moving around, say), but return to their original state at regular intervals – forever and ever.

Making time crystals

Although Wilczek's original notion of time crystals proved impossible to realise, a subset of them, called discrete time crystals, did seem to be feasible. In 2021, teams of scientists at Stanford University in California, Google Quantum AI, the Max Planck Institute for Physics of Complex Systems in Dresden, Germany, and the University of Oxford created a time crystal using Google's Sycamore quantum-computing processor. The states that were produced in the qubits displayed exactly the periodic behaviour in time predicted for quantum discrete time crystals.

So was it a real time crystal? “We spent a while grappling with this question,” says Matteo Ippoliti, a member of the Stanford team. Quantum computing “is blurring these lines”, he says, “and there is ongoing debate in

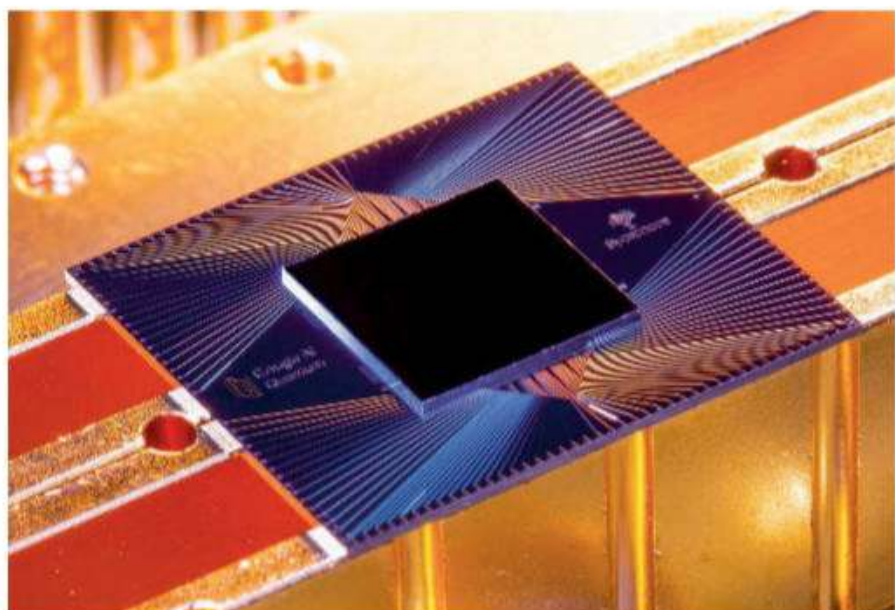
the community about terminology.” But he adds that there is a distinction between simulating a quantum time crystal on a classical computer and what his team did. “In the former case, a physical system – the classical computer – evolves in a way that looks nothing like the physics we're interested in, but nevertheless outputs numbers that replicate the outcomes of a hypothetical experiment.” Yet using a quantum computer in the way the researchers did “is itself an experiment”, he says, because it involves quantum objects (the qubits) doing what they are supposed to in a time crystal.

Quantum information theorist Seth Lloyd at the Massachusetts Institute of Technology thinks similarly. The question is whether the qubits are at all times doing what is expected of the system they are modelling. In the nonabelion case, they do, he says. But if they don't, it is a simulation.

Physicist Norman Yao at the University of California, Berkeley, a specialist in collective quantum behaviour, says he finds the distinction between quantum simulation and quantum reality tough. “It's all shades of grey,” he says. For him, it comes down to a question of usefulness. The reason we are interested in room-temperature superconductors, say, is to transport electricity without losses or to levitate high-speed trains. But if you got a bunch of qubits into the wave function corresponding to a superconducting state, you could never use it to do any of those things. The nonabelions, on the other hand, “are probably just as useable” for error-resistant, or topological, quantum computation as making them in some solid-state material, says Yao. “That, to me, makes the answer to the question ‘Have they braided non-Abelian anyons?’ a yes.” Still, there is the nagging issue of a real-world system to compare against. Yao admits that if we had already made nonabelions in lots of real materials, “my gut feeling would be different.”

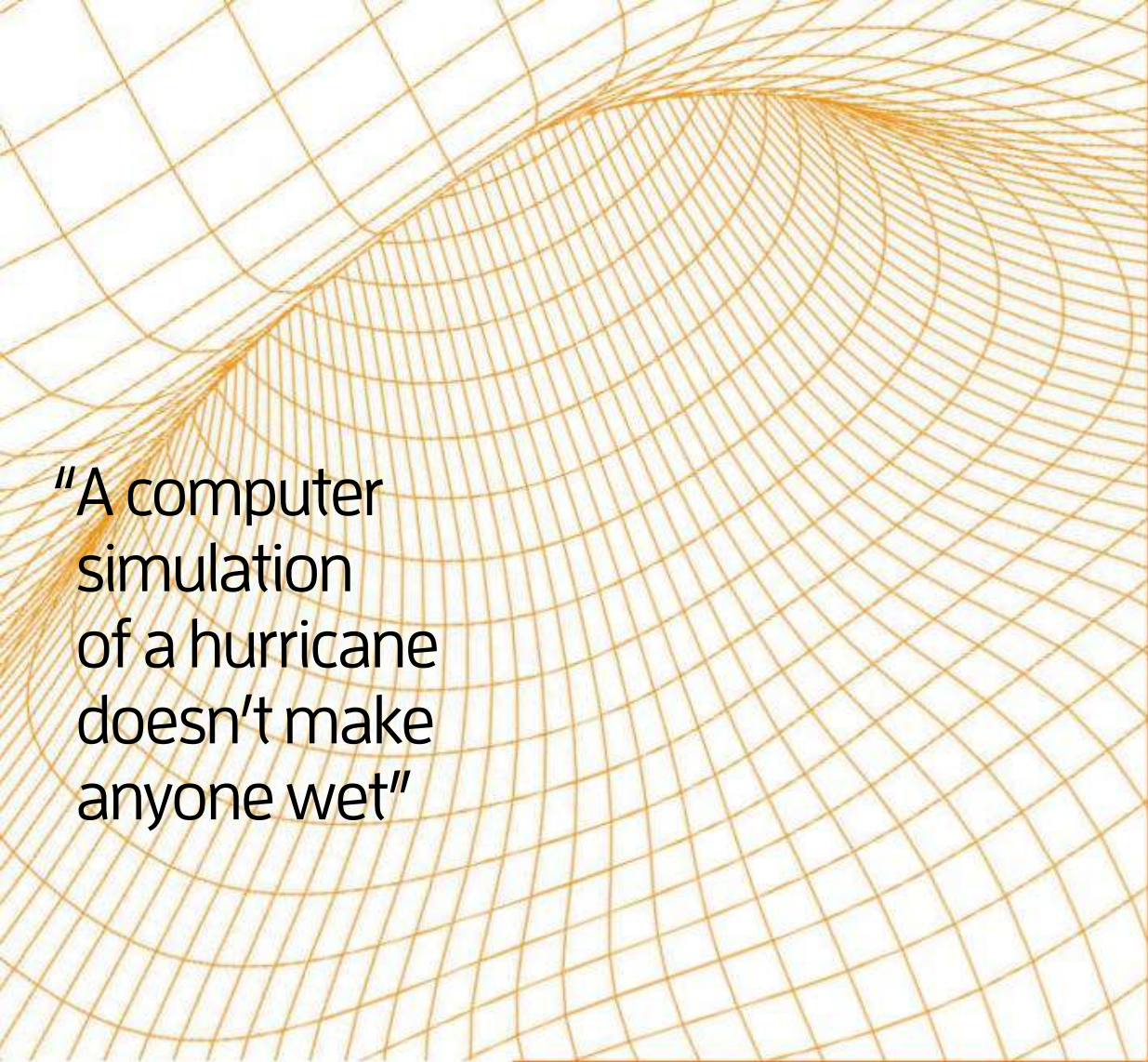
Now let's consider the wormhole incident. What Spiropulu and her colleagues did relates to a long-standing puzzle at the heart of physics: while space and time are described by general relativity as being smooth and continuous, quantum mechanics paints nature as fundamentally discrete and grainy. Can the two views be reconciled in a theory of quantum gravity?

One of the approaches considered most promising posits that we live in a hologram,



ERIK LUCERO/GOOGLE

Google's Sycamore chip was used to simulate a wormhole



"A computer simulation of a hurricane doesn't make anyone wet"

A wormhole simulated on a quantum computer isn't a tunnel through space-time

ESTAR 2020/SHUTTERSTOCK

based on something called the AdS/CFT correspondence. First proposed in 1997 by theoretical physicist Juan Maldacena, this asserts a relationship between a kind of space-time geometry called an anti-de Sitter space that arises in general relativity and a class of quantum field theories. In effect, it means that if you project the information in the anti-de Sitter space onto its own boundary, that information takes a form that looks a lot like a quantum field theory. The AdS/CFT conjecture is, in other words, a possible way to bridge the chasm between smooth relativistic space-time and the grainy quantum world. One possible implication of this idea is that space-time itself can be considered to be woven out of the web of entangled quantum particles.

Heady stuff. But if the conjecture is right, it is possible to translate the description of a wormhole in space-time as supplied by general relativity – a shortcut between different regions of space – into a set of correlations between entangled qubits. Set up such correlations between the qubits of a quantum computer, and AdS/CFT says that this is formally equivalent to a kind of wormhole. You could even transfer – or “teleport” – information between the entangled qubits in a way that looks equivalent, in this view, to sending it through a wormhole.

This is more or less what Spiropulu and her colleagues did, though they actually used something called the SYK model to set up their qubits, which is a simplified “toy” approximation of the AdS/CFT correspondence. They set up their experiment using nine of the qubits on Google's Sycamore chip and found that quantum teleportation of information between qubits “through the wormhole” produced the predicted signal of this equivalence. The title of their paper, published in *Nature*, sounds like something out of science fiction: “Traversable wormhole dynamics on a quantum processor”.

Alternative realities

There is quite a difference here from the work on nonabelions and time crystals. Not only is the SYK model a simplified version of the AdS/CFT description of quantum gravity, but furthermore the correspondence between general relativity and quantum field theory supposed by AdS/CFT is purely hypothetical, not least because our own universe isn't thought to have anti-de Sitter space-time.

So the issue here isn't so much whether making some quantum state from qubits is making the thing itself, but whether that thing bears any relation to physical reality.

A wormhole is generally understood to be a part of space-time that enables particular operations, like travelling from here to there in a single leap. Numbers output from a quantum chip don't let you do any of that.

“I think no one would be impressed by claims that scientists had ‘created a wormhole’ if it turned out that all they had done was to program a simulation of a wormhole on a classical computer,” says Aaronson. “And I reject the idea that simulating a wormhole on a quantum computer makes the situation fundamentally different.” *New Scientist* invited Spiropulu to reply to these critiques, but she didn't respond.

Wormholes aside, if there is something in the idea of processes in a quantum computer corresponding to “reality”, how far could it go? It is a question that has motivated science-fiction writers for years. In the latest series of Netflix show *Black Mirror*, for example, the “Joan is Awful” episode features an alternative reality created on a quantum computer that feels totally real to the characters within it.

On the principle that we are physical stuff made of atoms that a quantum simulation would need to be mapped onto, such a computed “alternative reality” would indeed be just a simulation. But some researchers have argued that all of reality is, in the end, basically a giant quantum wave function describing patterns of quantum information. From this cosmic perspective, things get a little blurry: what would make one wave function “more real” than another? Indeed, some people believe there is a more than a fair chance this is all we are – a quantum simulation created by an alien superintelligence.

But then, as Lloyd puts it: “If the simulation is indistinguishable from reality, the question of whether we live in a simulation or are just ourselves is not empirically decidable, and we need other criteria to form a judgment.” He suggests that we employ Occam's razor, which states that the simplest explanation is usually the best. “In this case, Occam's razor suggests that we just are ourselves,” he says. Lab-made quantum wormholes may not be real, but there is no good reason to doubt that you are. ■



Philip Ball is a science writer based in London

Puzzles

Try our crossword, quick quiz and logic puzzle **p45**

Almost the last word

Do shadows weigh anything or affect the weight of objects? **p46**

Tom Gauld for New Scientist

A cartoonist's take on the world **p47**

Feedback

Not seeing eye to eye and pooh-poohing papers **p48**

Twisteddoodles for New Scientist

Picturing the lighter side of life **p48**

Stargazing at home

Ring it in

Seeing Saturn's rings through a telescope can be an awe-inspiring experience. Now is a great time to spot them, says **Abigail Beall**



Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

What you need

A telescope with at least 40x magnification

ONE of my favourite stargazing memories is the first time I viewed the rings of Saturn through a telescope. The planet, with its iconic shape, came into focus before my eyes, and I was looking at it in real time.

In reality, what I was seeing was just over an hour in the past, as light from Saturn takes over an hour to reach us on Earth.

This was a few years ago, but even to this day I feel a sense of awe when looking at the gas giants Jupiter and Saturn through binoculars or a telescope.

People frequently ask me what size of telescope you need to see the rings of Saturn. We are often advised that you are able to see them through any small telescope, or even binoculars. But you really need a telescope with at least 40 times magnification to clearly see the detail of the rings as separate from the planet. And the bigger the telescope, the better.

You probably won't have any luck with binoculars. The best you can hope for is to see that Saturn is a disc, with something unusual at either side. There are plenty of other wonders you can see with binoculars however, like the moons of Jupiter.

You don't need any equipment to see Saturn itself though. The gas giant has been gradually making more of an appearance in our night skies for the past few months, and in mid-August it will rise in the east as soon as the sun has set, regardless of where you are in the world. A few hours later, it will be followed by Jupiter.



NASA, ESA, A. SIMON (GSFC)/OPAL TEAM

To find Saturn, look east just after sunset, and you will spot a bright "star". Look closely and you will see it isn't flickering. Use a free stargazing app to make sure you know exactly where Saturn is from your part of the world, because it will change over time.

Once you have found the planet, point your telescope in its direction and focus it. You might be tempted to magnify your telescope as much as possible with your choice of eyepiece, but try to resist this urge – too much magnification will just increase the distortion caused by light bending on its way through our atmosphere, making the image appear blurry.

Through smaller telescopes, Saturn's rings will appear as a cream-coloured fuzzy line

coming out from a central yellowy blob. With larger telescopes, you might be able to make out the black band of the Cassini Division, the gap between the A and B rings.

Whatever you can see, enjoy the experience. I think that Saturn through a telescope looks almost cartoon-like, and some say it is the most three-dimensional-looking object you can view in the night sky, because of the shadow the rings cast on the planet's surface.

While you are gazing at Saturn, take a look nearby and you will probably spot Titan, and perhaps some of the planet's other moons too. ■

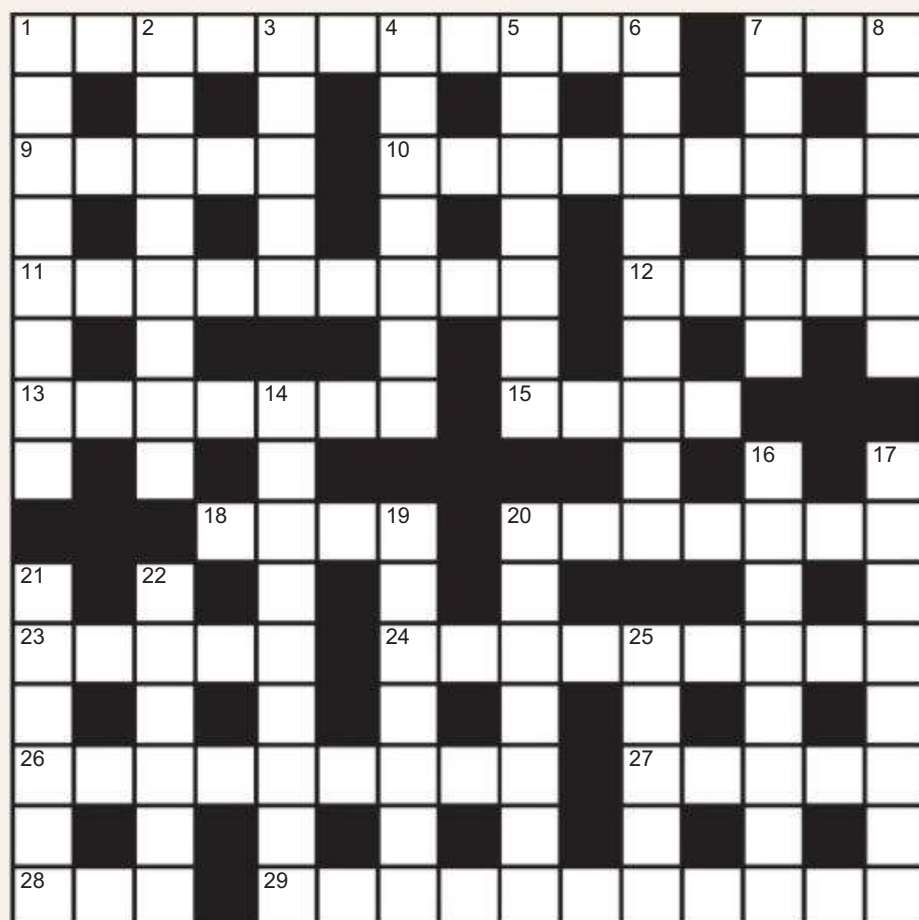
Stargazing at home appears every four weeks. Share your stargazing successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistStargazing

Next week

Mathematics of life

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Quick crossword #139 Set by Richard Smyth



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

- 1** Instrument that measures curvature (11)
7 Eucalyptus (3)
9/27 British science writer, author of *Fermat's Last Theorem* (5,5)
10 Danish quantum physicist (5,4)
11 Skull cavity that contains the apparatus for hearing (6,3)
12 ___ exclusion principle, rule in quantum physics first formulated in 1925 (5)
13 Strip of land between larger landmasses (7)
15 Elementary particle, μ (4)
18 Metal fastener or bolt (4)
20 Sixth semiprime (7)
23 Pulsate (5)
24 Orkney wreck site (5,4)
26 Springy; rubbery (9)
27 See 9 across
28 G-type main-sequence star 1.496×10^8 km from Earth (3)
29 Computer text function (3-3-5)

DOWN

- 1** Bone embedded within a tendon or muscle (8)
2 Concentration of atmospheric water vapour (8)
3 Relating to the kidneys (5)
4 William F. ___, US designer of fairground rides (7)
5 Provable mathematical statement (7)
6 Resistant to oxidation (9)
7 Mature; age (4,2)
8 Small falcon; British fighter aeroplane engine (6)
14 Relating to the conversion of food to energy (9)
16 Bogs, fens etc (8)
17 ___ hare, mammal of North America (8)
19 Take apart, surgically (7)
20 Squash (7)
21 Womb (6)
22 Inverse trigonometric function (6)
25 Pseudonym of US puzzle inventor Jim Propp (5)

Quick quiz #214

set by Bethan Ackerley

- 1** In geology, connate fluids are associated with which type of rock?
2 How many hexagons are there in the structure of a buckyball?
3 Cirripedology is the study of which arthropods?
4 The word "parsec" is a portmanteau of which phrase?
5 Fossils of *Australopithecus afarensis* have been found in Ethiopia, Tanzania and which other country?

Answers on page 47

Headscratcher

set by Brian Hobbs

#234 Remember December

"Happy anniversary, Craig," said Maria. "Do you remember when we first started dating? You brought me hot chocolate every Monday in December that year."

"Yes," replied Craig, "and you brought me your homemade caramel corn every Thursday that December as well, because you just couldn't let the month go by without there being an exactly equal exchange of gifts."

"I've always needed the symmetry," she said, smiling.

"Our first kiss was New Year's Eve, which I believe was on... Tuesday? Wednesday? Well, I can't remember what day of the week it was."

Maria pondered this for a moment. "We don't need to remember. I think we've already said enough for us to figure out which day of the week it was."

On which day did Craig and Maria have their first kiss?

Solution next week



Our crosswords are now solvable online
newscientist.com/crosswords

A bit shady

**Do shadows weigh anything?
And do they affect the weight
of objects they are cast over?**

Ron Dippold

San Diego, California, US

Shadows weigh nothing but can have apparent negative weight.

Consider what a shadow is: it is the lack of photons (light) bouncing off an area relative to the lit areas around it. Photons have no rest mass, but they do have energy – as encapsulated in the equation $E = mc^2$. A stream of photons delivers a force in the direction of travel when it bounces off a surface, as does a stream of water hitting an object. It is the principle behind the solar sail and has an effect on satellites in orbit.

Imagine you have a 1-square-metre, 1-kilogram piece of wood covered in silver foil (for maximum reflection), and you set that flat on an impossibly precise scale outside at high noon on the moon (so that we can ignore the effects of Earth's atmosphere).

“Imagine you have a piece of wood covered in silver foil, and you set it on an impossibly precise scale at high noon on the moon”

You tare the scale with the square on it, so it reads exactly 0 kg. Then you hold some space cardboard over it, blocking the sun. Now, the scale reads a little less than negative one millionth of a kilogram. Of course, it isn't that the shadow actually has negative weight, rather, the sunlight's downward pressure has apparent weight and you have blocked that.

Some caveats. This is all relative to the angle and intensity of the light and reflectivity of the surface. If the sun is at 45 degrees, then the downward force is only 71 per cent of what it is at high noon.

If the light is underneath an object, then a shadow on the bottom can even make that part



ANJOKANFOTOGRAFIE/GETTY IMAGES

This week's new questions

Holding hands If every human lined up facing north with their arms outstretched and touching, at what latitude would this closed circle be? **Robert Fizek**, Newton, Massachusetts, US

Leaving space What would happen to a galaxy should the black hole at its centre “leave” for whatever reason? **Peter Bennett**, Hastings, New Zealand

appear infinitesimally heavier than the bits around it that are being pushed up by the light. So, yes, shadows are weightless (they are just a lack of light), but they can affect apparent weight.

Guy Cox

Sydney, Australia

Shadows are the absence of light. Light consists of photons, which have no rest mass but do have energy, so they can exert a force on whatever they hit.

In other words, as photons are blocked to create a shadow, it effectively has negative mass. You would need a pretty sophisticated system to measure this, though.

Hillary Shaw

Newport, Shropshire, UK

Your shadow has a tiny negative

weight, but this doesn't affect what you are passing over.

The intensity of solar radiation per square metre at the top of our atmosphere is 1360 watts per square metre. This will be lower at ground level due to cloud cover, more so if the sun is low.

Your shadow isn't totally dark, either, but is lit by light scattering and reflecting from nearby air and surfaces. Let's say light intensity inside the shadow is reduced by 50 per cent compared with the intensity outside it.

The cross-sectional area you present to the sun to cause a shadow will vary from almost zero when the sun is at its zenith to around 0.5 square metres when it is at the horizon. Assuming an average shadow area of 0.3 square metres, we have a light reduction

If we all lined up with our arms touching, at what latitude would this closed circle be?

in your shadow of some 250 watts (joules per second). Using $E = mc^2$, the energy blocked each second is equivalent to a mass of about 2.5×10^{-15} kilograms. That means, every second, there is an energy deficit in your shadow equivalent to the mass of one bacterium.

This will move as you or the sun moves, and it is mitigated by a small energy inflow from sunlit areas nearby. However, that energy is absorbed by you, increasing your weight by the same amount, so the net effect on the surface you are on is zero.

Mark Dirnhuber

Bristol, UK

The cheap answer is that shadows have negative weight, so an object that is illuminated from above will weigh more than it would in the shade.

This is because of the phenomenon of radiation pressure. The idea is that light, or any electromagnetic radiation, possesses momentum, which is absorbed or even reflected back with the light. Given that force is the rate of change of momentum, the transfer of momentum will press the object down, increasing its apparent weight.

That light has momentum can be explained by classical physics as due to the interaction of its electric and magnetic fields with the charged particles in the object. It might be even more intuitively explained by quantum physics as the result of the volley of photons pressing down on the object.

This effect, which was first measured around the year 1900, is ordinarily extremely weak, but the pressure generated through it by sunlight must be included in the calculation of the trajectories of interplanetary space probes, and it is largely responsible for the fact that a comet's tail always points away from the sun, even when the comet is receding from the sun.



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Tom Gauld
for *New Scientist*



Sticking point

Why does runny honey stop dripping when there is still plenty left on the spoon?

David Muir
Edinburgh, UK

There are two competing forces at play here: viscosity and gravity.

Gravity is pulling the molecules in the honey downwards and causing them to separate and start flowing. On the other hand, intermolecular forces between the particles within the honey resist the flowing motion, and the viscosity of the honey is directly proportional to their strength.

The honey stops dripping when the intermolecular forces between its molecules overcome gravity. The intermolecular forces in petrol (gasoline), for example, are much weaker, so it is much more runny than honey.

You can see the tug-of-war between viscosity and gravity with water. Fill up a bottle with water to the very top. Keep adding drops of water until the meniscus, the

“Most people who wrongly remember my name, Garry, call me Harry or Larry. But a significant number call me Greg”

curve on the surface, protrudes above the lip of the bottle. At that point, viscosity is in ascendancy. Add a few more drops and gravity takes over.

Mark Thompson
Tewkesbury, Gloucestershire, UK
When I was a wee lad my mum was fascinated by the honey dipper and spoons.

We kids loved it because she would toast muffins and try to fill the individual holes. All I can remember is the dipper almost always caused the holes to fill, the spoon less so – so the fight was on to have the dipper muffin, yum!

Word memory

When I read a word that I don’t know how to pronounce, I can’t

remember it. Why do I need to be able to pronounce a word for my brain to recall it? (continued)

Garry Trethewey
Arkaroola, South Australia
Most people who wrongly remember my name, Garry, call me Harry, Larry or something similar. They sound the same.

But a significant number of people call me Greg, which sounds nothing similar.

I have thought about their process: a leading capital “G”, a middle bit with an “r” and a vowel, and a final letter with a dangling tail. So I think they are remembering visually.

David Werdegarr
Naperville, Illinois, US
As a budding scientist, it was natural for me to hyphenate mono-valent, di-valent and tri-valent.

Never having heard ambivalent spoken, I naturally did the same teaching my first statistics class. The laughter was both deafening and embarrassing. ■

Answers

Quick quiz #214 Answers

- 1** Sedimentary rocks. They are expelled as the rocks form.
- 2** 20
- 3** Barnacles
- 4** “Parallax of one second.” It was coined by Herbert Hall Turner in 1913.
- 5** Kenya

Cryptic crossword #115 Answers

ACROSS **1** Faraday, **5** Wears, **8** Lodge, **9** Amanita, **10** Ottoman, **12** Inner, **13** Tartan, **15** Aghast, **18** Salve, **19** Achieve, **21** Aneroid, **22** Let go, **24** Paste, **25** Maxwell

DOWN **1** Fell out, **2** Rod, **3** Dream, **4** Yearns, **5** Weaving, **6** Alien race, **7** Stair, **11** Thrillers, **14** Acetone, **16** Trefoil, **17** Random, **18** Scamp, **20** Helix, **23** Toe

#233 An odd league Solution

Five goals were scored in total.

The four “odd” teams (call them A, B, D, E) must have seven, five, three and one points, and since there were 20 points available, team C must have earned four. For the lowest number of goals, drawn games must end 0-0 and the rest 1-0. If teams A, B and C beat E, and A beat C and D while all the other games were draws, this is the final table (where F stands for goals for and A for goals against):

	W	D	L	F	A	Pts
A	3	1	0	3	0	7
B	1	3	0	1	0	5
C	1	2	1	1	1	4
D	0	3	1	0	1	3
E	0	1	3	0	3	1

Suspicious eyes

In the year 2001, US president George W. Bush foreshadowed a hope that decades later would pervade the robotics industry. Bush stood next to Russian president Vladimir Putin at a press conference in Slovenia and said of him: "I looked the man in the eye. I found him to be very straightforward and trustworthy... I was able to get a sense of his soul."

In the period since then, roboticists have theorised that putting eyes (or at least things that look like eyes) on robots would induce people to trust those robots. Trust them more, that is, than they would trust an eyeless counterpart.

Now, Artur Pilacinski and his team of robot researchers at the Ruhr University Bochum, Germany, and the University of Coimbra, Portugal, have tested the eyes/trust assumption.

They discovered that eyes did induce some people to have some trust in some robots. But it was less reliable trust, they concluded, than meets the eye. Their report, called "The robot eyes don't have it. The presence of eyes on collaborative robots yields marginally higher user trust but lower performance", appears in the journal *Heliyon*.

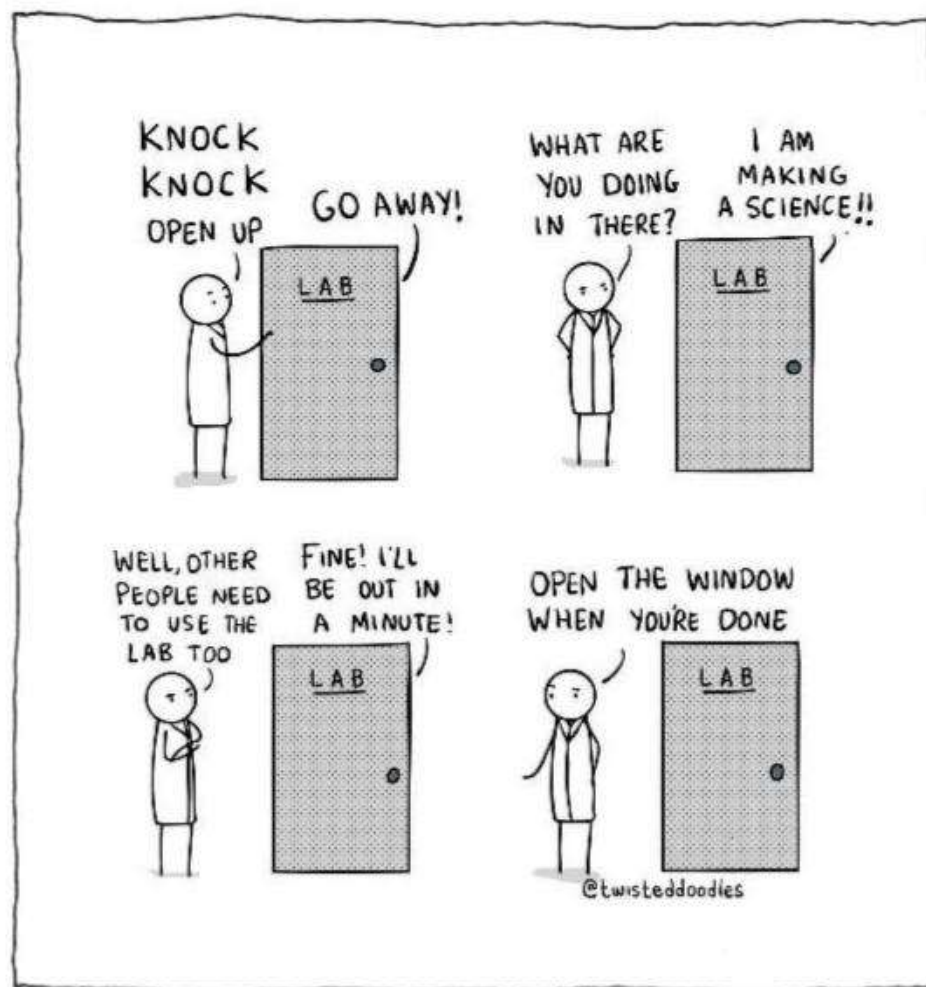
"We found," they say about collaboration with eyed robots, that "the objective markers such as pupil size and task completion time indicated it was in fact less comfortable to collaborate with eyed robots".

The worth of this visionary engineering idea, like Bush's sense, remains to be seen.

Whom Dad saw

Tom Marinov adds spousal-history detection and discernment to Feedback's growing record of trivial superpowers. He says: "My mother Zdravka could guess who my father had met during that day on his travels in Canberra. Sometimes these were friends he had not seen in many years.

Twisteddoodles for New Scientist



Got a story for Feedback?

Send it to feedback@newscientist.com

or New Scientist, 9 Derry Street, London, W8 5HY

Consideration of items sent in the post will be delayed

He would wager something, and she always got it in three."

Poo-pooping proofs

The year 2023 has already produced three, maybe four scientific papers that – by existing – pooh-pooh the notion that all scientists are prudish.

The journal *Molecular Ecology Resources* gives us: "The proof is in the poo: Non-invasive method to detect endoparasitic infection."

Researchers in Illinois present their report: "The proof is in the poop: Colorectal cancer screening outreach and quality improvement."

And the Authorea preprint repository offers a counterpart: "The proof is in the poop: First density estimates for a recovering bobcat population in southeast Ohio using DNA from scat."

We can add a fourth to this

poo/poop/poop collection, if you allow triple-letter acronyms into the mix. A study presented at the 2023 4th International Conference for Emerging Technology is called "Proof of Opinion (PoO): A new consensus algorithm for decentralized blockchain networks".

The abstract begins with this icky-cutesy declaration: "This paper introduces the Proof of Opinion (PoO) consensus algorithm as an alternative to the traditional Proof of Work (PoW) and Proof of Stake (PoS) algorithms."

Apple appeal

Does an apple a day keep diseases away? There had never been a clear answer agreeable to the whole medical profession. Now, maybe there is.

A team of nine researchers based at Tianjin University of

Traditional Chinese Medicine in China gathered more than 200 apple-related medical studies from the past decade. They perused. They pondered. They published, in *Food Science and Nutrition*.

This study exemplifies a broad swathe of medical reports about a broad swathe of medical questions. It winds up with a rousing maybe-perhaps statement. "In conclusion," it says, "the effects of apples and apple derivatives on disease risk reduction are both challenging and encouraging."

Apples appeal to many hardcore scientists (as well as to Bible literalists and, of course, to anyone who has a literal taste for apples). They offer tantalisation and mystery, even – and maybe especially – to scientists who study brains. In a report called "The underpinning of meaningful activities by brain correlates", a team in Belgium invokes apples while explaining that "activities of daily living are difficult to perform in a lab or clinic".

The researchers point specifically to an activity that is the focus of a Japanese study called "Multimodal assessment of cortical activation during apple peeling by NIRS and fMRI".

The apple-peeling study shows how very difficult apple-centric research can be. It shows a photograph with the caption "A subject, lying supine in an fMRI environment, performs a mock-peeling task while observing his hands, an apple and a plastic knife model through a mirror".

Difficulty doesn't preclude progress, however. An Iranian study published in 2021 in the *Avicenna Journal of Dental Research* titled "Plaque removal efficacy of chewing apples and tooth-brushing" reveals one of the countless surprises apples offer to science.

"Chewing yellow apples," it says, "was discovered to be [a] more effective method in reducing dental plaque than chewing red apples or using toothbrushes." ■

Marc Abrahams

Amazing science-inspired tours



27 October 2023 | 8 days

Land of fire and ice: Iceland

Join an unforgettable tour of Iceland's majestic landscapes, timed to give you days filled with volcanic and geological adventure, and evening opportunities to see the Aurora Borealis.

Volcanologist Tamsin Mather and local guides will accompany you as you discover the awe-inspiring might of the planet and marvel at the sights, sounds and smells of erupting geysers, hot springs and bubbling fumaroles. You will get up close to stunning glaciers, waterfalls and tectonic plates pulling apart.

On four of the nights, you will be staying in stunning rural locations with little light pollution, so ideal for observing the Aurora Borealis. Plus you will spend the remaining nights in the world's northernmost capital, the coastal city of Reykjavik.



23 March 2024 | 15 days

The science of the deep Antarctic: Shackleton's expedition and the Weddell Sea

Join one of the greatest expedition voyages on this planet. Journey below the Antarctic Circle and deep into the ice-choked Weddell Sea, a part of Antarctica that few get to experience. Encounter huge tabular icebergs, and an array of marine wildlife on this trip of a lifetime to the world's most remote continent.

Exclusive to *New Scientist*, you will be accompanied by marine biologist and author Helen Scales along with a highly knowledgeable and supportive expedition team.

You will travel aboard a new state-of-the-art polar expedition vessel, the *Sylvia Earle*. With a capacity for just 132 guests, it is large enough to offer luxury and to navigate deep into the ice but remains an intimate and highly personalised experience. With a full programme of talks, shore visits and Zodiac boat safaris.



18 June 2024 | 13 days

Science of the Arctic expedition cruise: Norway

Join our marine expedition exploring the northernmost region of Earth, the realm of the polar bear and the midnight sun. Gain extensive knowledge of marine and polar nature while deepening your connection to this remote and rugged archipelago.

Witness polar bears on ice flows, beluga whales and a plethora of species on land, sea and in the air. Plus, you will explore the Arctic town of Longyearbyen.

Aboard a new state-of-the-art polar expedition vessel, the *Greg Mortimer*, you will experience the majesty of Norway's Svalbard with its ancient glaciers, glass-still fjords, imposing pack ice and distinct landscape where wildlife thrives at nearly 80° north.

With a full programme of talks, shore visits and Zodiac boat safaris. Accompanied by *New Scientist's* Rowan Hooper along with highly knowledgeable and supportive expedition team, experts in exploration, science, and wildlife.

Find out more and explore other fascinating voyages of discovery online at [newscientist.com/tours](https://www.newscientist.com/tours)

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